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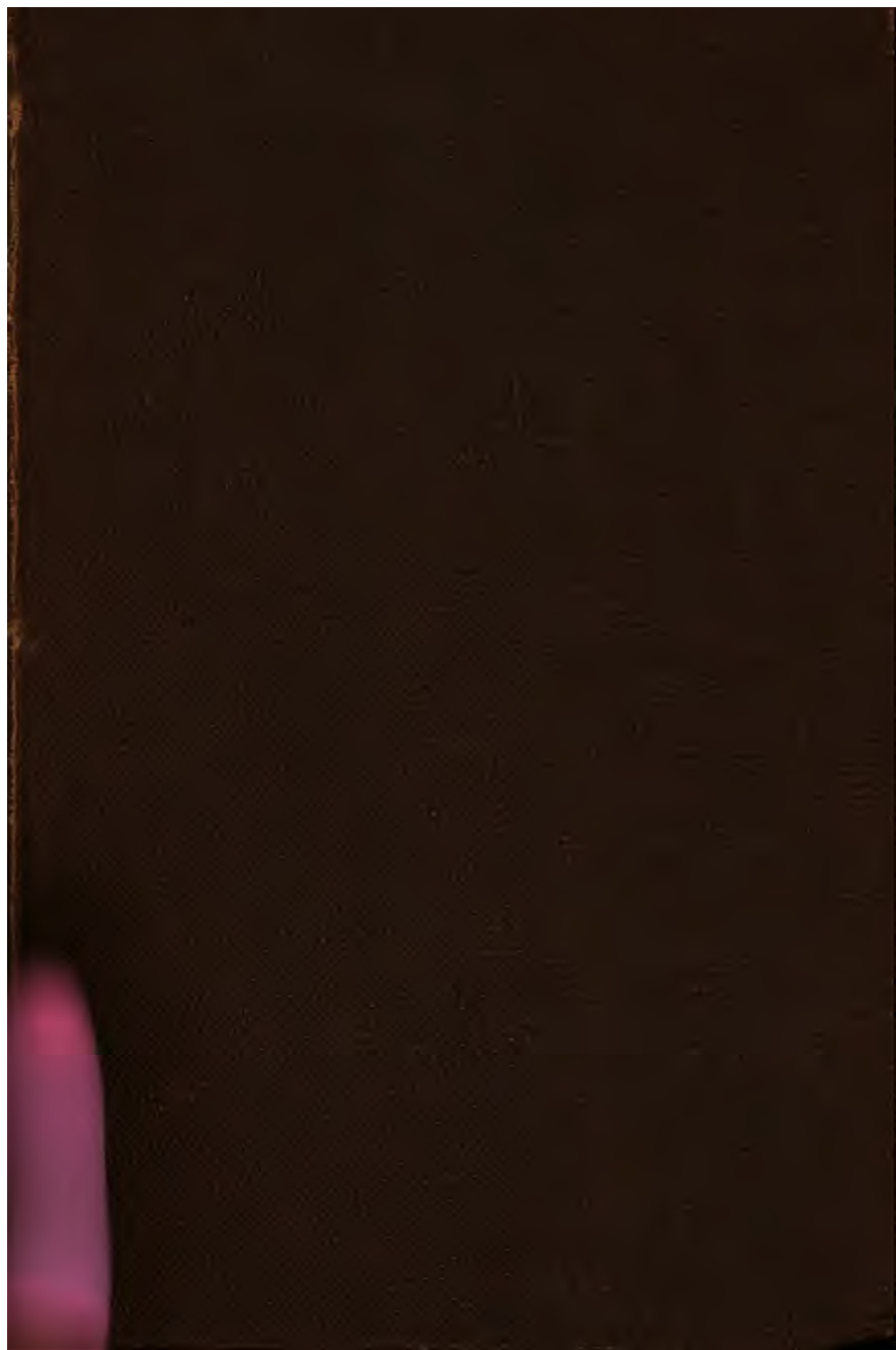
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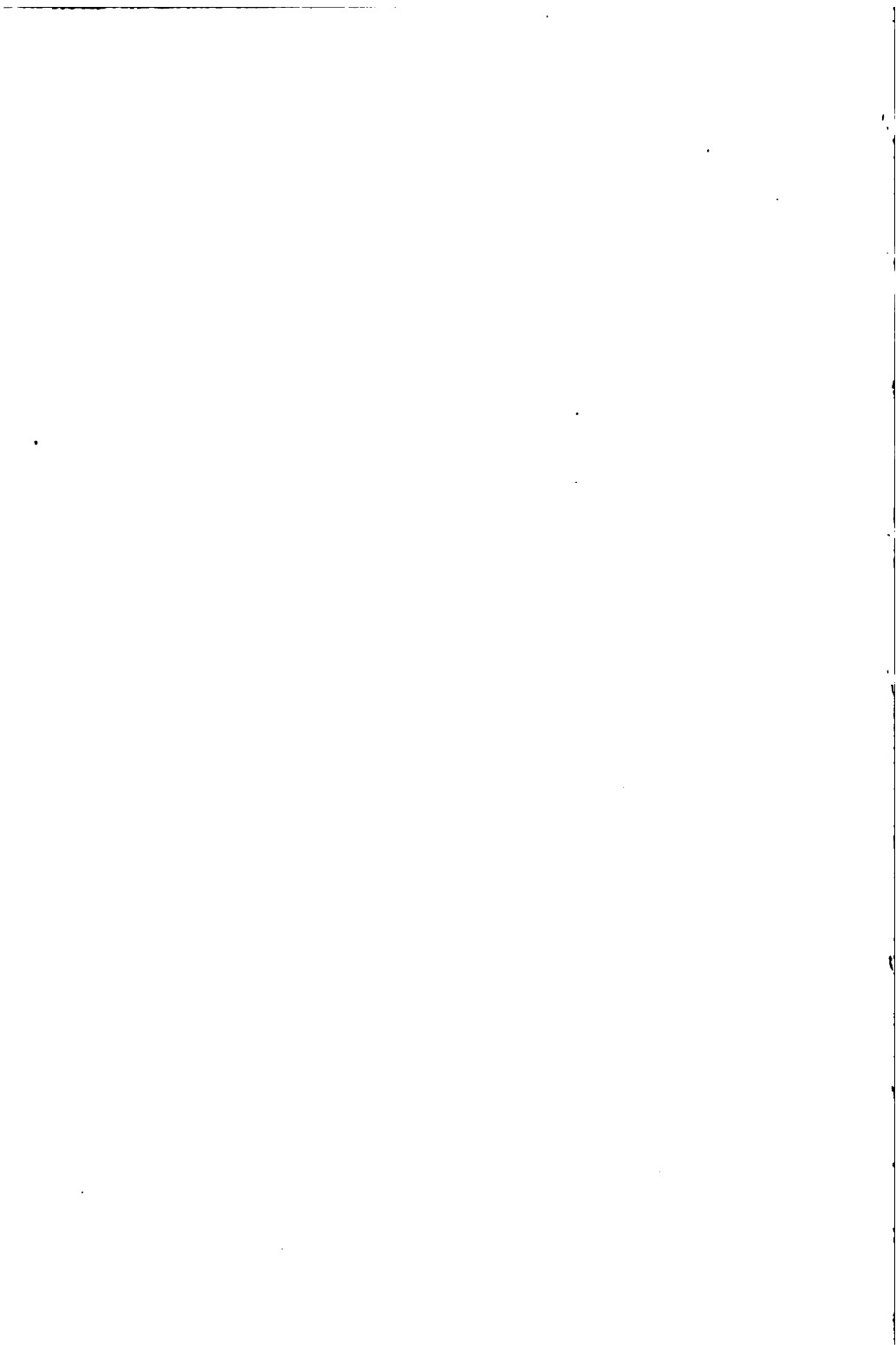
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PROCEEDINGS
OF THE
PHILOSOPHICAL SOCIETY
OF GLASGOW.

VOL. XIX.

1887-88.

EDITED BY THE SECRETARY.

PUBLISHED FOR THE SOCIETY BY
JOHN SMITH AND SON,
129 WEST GEORGE STREET, GLASGOW.
1888.

212926

VOL.	IX. (No. 1),	PRICE 2s. 6d.
Do.	IX. (No. 2),	„ 3s. 6d.
Do.	X. (No. 1),	„ 3s. 6d.
Do.	X. (No. 2),	„ 3s. 9d.
Do.	XI. (No. 1),	„ 4s. 0d.
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PROCEEDINGS
OF THE
PHILOSOPHICAL SOCIETY OF GLASGOW.

EIGHTY-FIFTH SESSION.

PRESIDENT'S ADDRESS.

I.—*On Some Sociological Aspects of Sanitation.* By JAMES B. RUSSELL, B.A., M.D., LL.D., President of the Society.

[Read before the Society, 2nd November, 1887.]

It is exactly a quarter of a century since I received my diploma as a member of this Society, signed by Professor Henry D. Rogers, President; Robert Hart, Vice-President; Wm. Cockey, Treasurer; and Alexander Hastie, Secretary. I had just graduated in medicine, and joined at the request of my much respected teacher, Dr. Bryce, of the High School. I remember well with what pride and pleasure I received the parchment, and took my seat in the room on the ground floor of Anderson's University, where the Society then met. I now acknowledge with gratitude how much I am indebted to the connection formed thus early in my career with the intellectual life of this great city, for the extension of my information beyond the restricted limits of my profession, and for personal intimacy with many of the men who have adorned, and who still adorn, the varied ranks of our citizenship. But if anyone had whispered to me on that December night, twenty-five years ago, that I should occupy the chair then filled by my former teacher, the Professor of Natural History in the University, and have to face the task which is now before me, I should have regarded the suggestion as but the kindly flattery with which friendship seeks to cheer the youth who thinks there is no room for him in the press of life. Even now I feel that I owe

my position more to your good-will than to my merits. I am deeply sensible of the high honour which you have conferred upon me. I thank you for it, and I shall endeavour, in co-operation with the other office-bearers, and with your assistance, to maintain the reputation and promote the general prosperity of the Society.

It is a wise usage of this Society which gives the president-elect a year in which he may enjoy the honours of his position without the labour of giving a set address. I confess, however, that this grateful space has been spent in a bewildered survey of the task rather than in a deliberate preparation for its fulfilment. Amid the various subjects which might fitly be brought before this Society, you will, I am sure, recognise my prudence in seeking to discharge my obligation to deliver a presidential address by discoursing to you on "Some Sociological Aspects of Sanitation."

It has happened to me, from time to time, in the course of my life, to have some learned friend shrug his shoulders and drop the hint that my official work, the ultimate object of which is the conservation of life, was somehow opposed to the laws of the universe. These criticisms generally included in their expression the phrases "struggle for existence," "natural selection," "survival of the fittest." I wish now to look into this grave suggestion. The ultimate source of these criticisms is Mr. Herbert Spencer, and I take their full exposition from his book, "Social Statics," and their more recent and popular reiteration in "The Man *versus* the State."

First let me acknowledge that I am heavily handicapped in my task by the personal interest which I have in opposing these doctrines—what Mr. Spencer calls the "class-bias," which he defines as "a reflex egoism."* It is, however, so far fortunate that I am "in the same condemnation" as the whole medical profession, who, we are told, "moved as are the projectors of a railway, who, whilst secretly hoping for salaries, persuade themselves and others that the proposed railway will be beneficial to the public—moved as all men are under such circumstances, by nine parts of self-interest gilt over with one part of philanthropy— . . . are vigorously striving to erect a medical establishment akin to our religious one."† I pass by these and other passages to the like effect with the remark that they are not fair. Doctors live by the treatment of disease, and if, as a body, they have been the chief

* "The Study of Sociology," 6th edition, p. 242.

† "Social Statics," 1868, p. 409.

advocates of methods of preventing disease, which is a historical fact, the circumstance that a small percentage of the total number have thereby obtained official emolument is but a decimal to the credit of the whole professional income against the vast sum which has been deducted by their aggregate efforts. I trust the allegation of "class-bias" will not prevent the merits of my argument from being considered.

Mr. Spencer sets out from the "law of right social relationships, that *every man has freedom to do all that he wills, provided he infringes not the equal freedom of any other man.*" * Again: "Here, then, we reach the ultimate interdict against meddling legislation. Reduced to its lowest terms, every proposal to interfere with citizens' activities further than by enforcing their mutual limitations, is a proposal to improve life by breaking through the fundamental conditions to life." † These principles are applied to the whole round of State legislation, as, for example, the Regulation of Commerce, Religious Establishments, Poor Laws, National Education, Government Colonization, and Sanitary Supervision. I have no fault to find with the principle, but I question some of its applications to sanitation. I agree heartily with much of the rigid, uncompromising, unanswerable criticism to which the interferences of the State in these various departments of legislation are subjected. Even sanitary legislation furnishes examples of blundering. I agree that the evolution of the individual is best promoted by leaving him, as far as consists with the general well-being, to his own deserts. Paternal government or grandmotherly legislation produces a poor weakling, maintained in the battle of life by artificial props outside of him. The natural incentives of rewards and deterrents of punishments are inoperative; and deterioration, moral and physical, is the aggregate result. But these are unsatisfactory generalities. It is only when we follow Mr. Spencer into the details of his method of dealing with public health that we can discover whither he would lead us. He maintains that it is not the duty of the State to protect the health of its subjects. Sanitary administration by the State is wrong. Sanitary administration by municipal authorities is wrong. All taxation for sanitary superintendence, being the abstraction from the citizen of more property than is needful for the efficient defence of his rights, is to be condemned. "Be it by general

* "Social Statics," p. 121.

† "The Man *versus* The State," p. 105.

government or by local government, the levying of compulsory rates for drainage, and for paving and lighting, is inadmissible, as indirectly making legislative protection more costly than necessary, or, in other words, turning it into aggression; and if so, it follows that neither the past, present, nor proposed methods of securing the health of towns are equitable." * Mr. Spencer proceeds: "This seems an awkward conclusion; nevertheless, as deducible from our general principle, we have no alternative but to take to it." Then he goes on to sketch a method of sanitation consistent, as he supposes, with his general principle. I give his own words, for although the passage is long, the best method of criticism is to do so:—"How streets and courts are rightly to be kept in order remains to be considered. Respecting sewerage there would be no difficulty. Houses might readily be drained on the same mercantile principle that they are now supplied with water. It is highly probable that in the hands of a private company the resulting manure would not only pay the cost of collection, but would yield a considerable profit. But if not, the return on the invested capital would be made up by charges to those whose houses were drained: the alternative of having their connections with the main sewer stopped being as good a security for payment as the analogous ones possessed by water and gas companies. Paving and lighting would properly fall to the management of house-owners. Were there no public provision for such conveniences, house-owners would quickly find it their interest to furnish them. Some speculative building society having set the example of improvement in this direction, competition would do the rest. Dwellings without proper footway before them, and with no lamps to show the tenants to their doors, would stand empty, when better accommodation was offered. And good paving and lighting having thus become essential, landlords would combine for the more economical supply of them." *

If you say this is impracticable, Mr. Spencer replies that therein lies the virtue of the scheme; for the impracticability arises from the imperfect morality of mankind, and perseverance in these impracticable methods will elevate the general morality until it becomes practicable. If you say, out of the intermediate chaos will arise disease, which will involve good and bad, moral and immoral, in one common destruction, he welcomes disease, especially

* "*Social Statics*," p. 430.

epidemic disease, as one of the saviours of society. "Partly by weeding out those of lowest development, and partly by subjecting those who remain to the never-ceasing discipline of experience, nature secures the growth of a race who shall both understand the conditions of existence, and be able to act up to them."* Again: "Mark how the diseased are dealt with. Consumptive patients, with lungs incompetent to perform the duties of lungs, people with assimilative organs that will not take up enough nutriment, people with defective hearts that break down under excitement of the circulation, people with any constitutional flaw preventing the due fulfilment of the conditions of life, are continually dying out, and leaving behind those fit for the climate, food, and habits to which they are born. Even the less imperfectly organised, who, under ordinary circumstances, can manage to live with comfort, are still the first to be carried off by epidemics; and only such as are robust enough to resist these—that is, only such as are tolerably well adapted to both the usual and incidental necessities of existence, remain. And thus is the race kept free from vitiation."† And thus we are introduced to "natural selection" and "the survival of the fittest." In "*Social Statics*" (p. 353 *et seq.*), we are desired to note how aged and infirm ruminants are killed and eaten by "their carnivorous enemies," and so the average happiness and well-being of both are promoted. In man, among other analogous processes, are specified "the beneficence which brings to early graves the children of diseased parents, and singles out the low-spirited, the intemperate, and the debilitated as the victims of an epidemic." In "*The Man versus The State*," written thirty-three years later, Mr. Spencer refers to Mr. Darwin's doctrine of "natural selection," promulgated in the interval, as strengthening his position, and expresses surprise that, despite the general acceptance of this doctrine by cultivated people, "now more than ever before in the history of the world, are they doing all they can to further survival of the unfittest."

In the first place, let us consider what is the comparative value of disease as a factor in natural selection in civilized man and in the lower animals? We must not think of disease, or rather its causes, merely as producing death, as we are apt to do when the elevation of the race by the extinction of the individual fills up our field of vision. Disease is not like the deer-stalker's bullet,

* "*Social Statics*," p. 413.

† "*Social Statics*," p. 414.

when his aim has been true, and one falls while all the rest of the herd gallop away unharmed. It resembles the discharge of "buck-shot" or "sparrow hail," which scatters, and for every one killed there are a number maimed. Granting, then, that the most unfit dies, round every *deceased* unfit there are a number *surviving* more or less unfit, because of the effects of disease. This is the invariable result of the action of disease or disease-producing agencies on life. But in the lower animals the predatory instincts of one order promote the development of another by killing and devouring its weaklings; and within the order itself sexual selection tends to isolate the individual from posterity. In civilized man the weaklings survive, and sexual selection does not effectively prevail. The analogy is perfect between the effects, immediate and remote, of a cartridge fired at a large covey and a volley on the battlefield, and the comparative value of disease as a factor in natural selection in these cases. In the former there are the dead which are bagged by the sportsman, and the wounded who are eaten before nightfall by hawks, weasels, cats, &c.; in the latter there are the dead who are buried, and the wounded who are carried away and survive with various deformities and injuries. If you want full evolutionary value out of disease in man, regarded merely as an animal, you must kill or seclude from society; but killing is murder, and sexual selection can only be promoted by the diffusion of knowledge and the elevation of morality to such a sublime pitch that the individual will limit his happiness, subdue his desires, and, in short, extinguish himself for the benefit of posterity. How far we are from this consummation no one has had a better opportunity of judging than Dr. Maudsley. Speaking of certain diseases having a strong hereditary tendency, he says:—"Those who, having fallen in love, are aware of the existence of them in their families, are, therefore, not a little troubled sometimes with scruples of conscience, and anxiously ask medical advice whether they shall marry or not. In the end they commonly marry, whatever the advice given them, having persuaded themselves that the epilepsy was not real epilepsy, but a form of strong hysteria; that the lung mischief was not constitutional phthisis, but the accidental consequence of a neglected cold; that the insanity was not the outcome of family degeneracy, but an incidental effect of a blow on the head, which was thought nothing of at the time. Would the earth ever have been peopled had cool reason been potent enough to quench the hot passion of

love?"* On the whole, then, from these premises I conclude that, in existing circumstances, the most efficacious and direct method of promoting the survival of the fittest in civilized man is to prevent disease of all kinds by the removal of its causes. Indeed, Mr. Spencer's argument from natural selection really strikes, not at *prevention* of disease, but at all forms of artificial interference with the tendencies of disease which maintain in life sick, crippled, and, in general, physically or morally impaired and unsound individuals.

So much for disease in general, but different diseases present different sociological aspects. Some begin and end in the individual, and do not descend vertically or spread laterally as morbid entities. Their value in the process of natural selection is confined to the extinction or the weakening of the staying-power of the individual. They exercise no direct physical influence on existing individuals, and on posterity only by impairing reproductive power, or diminishing the viability or the chances of vigorous and healthy life in the product of such parents. Simple inflammations, such as pleurisy and pneumonia, are illustrations of this class. Other diseases descend, or tend to descend, vertically. They are distinctly hereditary—as epilepsy, insanity, gout, consumption. Others, again, are remarkable for lateral extension, from person to person, from town to town, from country to country. These do not descend vertically, and they influence posterity only indirectly in the same ways as the first class. But they stand out as the most potent sociological disease-factors in virtue of their power of lateral extension or infectivity. You have no doubt remarked how frequently Mr. Spencer brings in epidemics as his ministers in the discipline of mankind, and, though I propose to derive quite other lessons as to their influence, we cannot over-estimate their teleological importance. I cannot display this feature of infectious disease in more apt and impressive words than those used by Dr. Farr, who says:—"Diseases of this class distinguish one country from another—one year from another; they have formed epochs in chronology; and, as Niebuhr has shown, have influenced not only the fate of cities, such as Athens and Florence, but of empires; they decimate armies, disable fleets; they take the lives of criminals that Justice has not condemned; they redouble the dangers of crowded hospitals; they infest the

* "Heredity in Health and Disease."—*Fortnightly Review*, May, 1886.

habitations of the poor, and strike the artisan in his strength down from comfort into helpless poverty; they carry away the infant from its mother's breast, and the old men at the end of life; but their direst eruptions are excessively fatal to men in the prime and vigour of age." This last statement is not exactly in harmony with what you have heard of "sweeping away by pestilence tens of thousands of unhealthy livers," or "weeding out those of lowest development."

But I must not anticipate. Let me endeavour to bring into bold relief those characteristics of a few of the chief communicable diseases which are of the highest sociological importance. I shall use the adjective "communicable," so as to concentrate your attention upon this characteristic, and get rid of the suggestion of theory as to its mode involved in the words "infectious" and "contagious." Let us first take *Smallpox*. This has been well described as "a murderous disease, beside which the loss through the bloodiest of wars, or through other severe pestilences, such as plague and cholera, appears to be infinitesimally small."* It is cosmopolitan in its distribution. Wherever its virus reaches a susceptible population there it becomes epidemic, and it is without discrimination in the choice of its victims. All ranks, ages, and conditions of men succumb—the rich, the poor; the healthy, the "unhealthy livers"; the clean, the dirty; the virtuous, the profligate; the learned, the ignorant. Smallpox lends itself to no more refined social function than the killing and maiming of mankind; for no disease inflicts more damage on survivors. The virus may be carried great distances by persons and by things. I have myself seen smallpox imported into Glasgow from France, from America, and even from India, as well as by rags brought from no one knows where. It acknowledges no control but that of compulsory vaccination and revaccination, to which, however, happily it yields abject submission.

"After smallpox and influenza," says Hirsch, "we know no acute infective disease which has, on the whole, attained so wide a diffusion over the globe as *Cholera*, from the tropics to extreme polar latitudes; and has carried with it, amidst all the differences of climate, soil, and social well-being, so complete a stamp of uniformity in its fundamental characters, in its natural history, in

* Hirsch, "Handbook of Geographical and Historical Pathology." New Sydenham Society, Vol. I., p. 140.

its type, and in its fatality,—and that, too, both in epidemics great and small, and in sporadic cases.”* Its habitat is India, probably Lower Bengal. That is to say, cholera always prevails there, lives there, so to speak, and thence makes periodic raids over the world, sometimes establishing itself in outposts from which secondary raids are made, but ultimately disappearing everywhere, and retiring upon India. There are, nevertheless, large tracts of country which have never been invaded by cholera. Australia is a conspicuous example; but of the majority of such fortunate places their peculiar isolation is obvious; and many exceptions in the earlier epidemics have in subsequent ones lost their immunity. Still there are cases of local exemption, which do not seem to be explicable by anything for which the inhabitants can claim credit, but depend upon such physical features as altitude, sub-soil, &c. As to individual predisposition, cholera is most deadly among the negro race, but “those groups or classes of the population most exposed to the injurious influences that appear to be especially adapted to weaken or destroy the power of resistance are at the same time in greatest risk of the disease.” This is probably a mere corollary to the proposition that “cholera derives all its epidemic destructiveness from filth, and especially from excremental uncleanness,” this being a cause which saps the strength from year to year between the epidemic explosions. Cholera has been, and is, the most cogent and successful apostle of sanitation this country has ever seen. A public statue has been frequently awarded for less important services. Every sanitary official knows that when the administrative machinery is running down, and arrears of unremoved nuisances accumulate, nothing restores the motive power so effectively as the apparition of the grim visage of cholera upon the eastern horizon.

Yellow Fever epidemics are limited to the shores of the Gulf of Mexico (including the West Indies), to part of the Atlantic coast of the United States, to the Atlantic and Pacific coasts of South America, to the west coast of Africa, and to parts of Spain. There are three habitats or breeding places whence it spreads from time to time, namely:—the West Indies, the Mexican Gulf coast, and Sierra Leone. “In almost all the places where yellow fever has been prevalent hitherto—equally the indigenous fever and the imported—there are certain points from which the epidemic has

* Hirsch, *Op. cit.*, Vol. I., p. 438.

always started; and those points are found to be, in seaports, the immediate neighbourhood of the harbour and the wharves, and, generally speaking, *the filthy quarters of the town*, the centres of poverty, misery, and vice, with their narrow and foul-smelling streets, their tenements densely crowded from cellar to garret, their taverns, dancing saloons, and lodging-houses. It is after the epidemic has come to a head in those purlieus that it begins to spread, always in the first instance into the immediate neighbourhood; but not unfrequently it remains confined to them, and the other parts of the town, some distance off, and better situated hygienically, may be little troubled by the sickness, or not at all.* Yellow fever travels from these regions with ships, and seems not only to cling to persons, but to the ship itself, its cargo, and luggage. It spreads from these ports with the land traffic by the same media, but clings close to the rivers and does not go far inland. On shore it forms foci in houses, and everyone who enters those foci is liable to attack. These being the well ascertained though imperfectly understood habits of yellow fever, it paralyses all commercial and social intercourse, and, in fact, brings ruin and social dissolution wherever it goes. There is no interference with personal liberty which local authorities in America will not adopt to keep it out, even to what they call with characteristic plainness "shot-gun quarantine."

The history of the *Plague* or *Black Death* takes us into times when records are so deficient, and into regions where exact information is so difficult to be had that it is scarcely possible to arrive at precise conclusions as to its primary habitats. It is enough for our present purposes to say that it had, like the great majority of communicable diseases, habitats where it flourished, and from which it made periodical raids upon surrounding countries, spreading with goods and passengers. These were in the East, and the conditions to which it was native are those with which we are so familiar—filth, overcrowding, and general wretchedness and misery in the domestic condition of the people.

We shall now turn to communicable diseases which are well known in our own country. *Measles* is distributed over almost the whole habitable globe. As in the case of smallpox, the occurrence of an epidemic depends solely upon the conjunction of a susceptible population, and the introduction of the specific poison. It affects children chiefly, but in islands and isolated

* Hirsch, *Op. cit.*, Vol. I., p. 360.

regions, where persons have grown up without being exposed to the disease, measles attacks the whole population, and may prove very fatal even to adults. Where domestic comforts are few, and the hygienic surroundings bad, it is very destructive of child-life, and the survivors are often seriously injured. The mean age of persons dying of measles in this country is only 2·7 years.

Scarlet Fever is chiefly a European disease. It is but scantily diffused in Asia and Africa. In North and South America, and in Australia and Polynesia, it is more or less prevalent. This disease presents many puzzling irregularities, both of incidence and fatality. It never wholly disappears from our large towns, where it spurts out into epidemics at uncertain intervals. Bad sanitary conditions no doubt aggravate the risks of this, as of every disease, but scarlet fever proves fatal where no such defects exist; and in many epidemics the poorest districts escape, or the respectable poor and the better classes suffer most severely. Hirsch sums up the results of his study of the literature of the subject thus:—"Scarlet fever shows itself to be independent of climate, season, weather, and influences of locality, not only as regards its distribution area, but also as regards its intensity, or *the mild or malignant type of the epidemic*. Just as little, speaking generally, do *hygienic defects* arising from social conditions appear to exert any definite influence on the character of the sickness."* Recent observations tending to prove that scarlet fever may originate in the use of milk derived from cows suffering from a slight febrile affection, which produces little obvious effect on the condition of the cow, may explain these anomalies. Such a discovery would account for the heavier incidence of some epidemics upon those who can afford to be consumers of milk, and give a new teleological aspect to scarlet fever. Wherever the primary habitat of this disease may be, and however it is established, the subsequent diffusion of the poison is far-reaching and subtle, especially in populous places; and the safety of all classes is jeopardized by individual ignorance and carelessness. The mean age of persons who die of scarlet fever in this country is 5·8 years.

Whooping-cough is found all over the globe, except in a few isolated places, such as Iceland, where only a rare imported case has been observed. Being a disease whose severity depends upon complications arising from inflammatory affections of the respiratory

* Hirsch, *Op. cit.*, Vol. I., p. 187.

organs, its fatality, if not its prevalence, depends upon local climate—especially upon such befouled conditions of the general atmosphere as are found in large coal-burning cities, and of the domestic atmosphere as arise from overcrowding. Hence, although whooping-cough attacks all persons unprotected by previous seizure, without modification by physical, social, or racial circumstances, it is most fatal to the poor, and the survivors are often seriously and permanently impaired in health. The specific poison is one of the most communicable of all such poisons, and the sufferers not being so seriously ill as to prevent them from moving or being carried about in society, it seems to be impossible by any tolerable or even practicable amount of interference with personal liberty to control its dissemination. The mean age of fatal cases of whooping-cough is only 1·8 years in this country. Of all the communicable diseases it is the most destructive of infant life, especially in cities.

Diphtheria is a disease which has a curious history. It can be identified and traced under various names back to remote antiquity, but it seems to disappear from the records of disease at the end of the 18th century. It probably never wholly left France. It certainly reappears early in this century, first in the writings of French physicians; and from time to time isolated outbreaks are noted in different parts of Europe and America. But between 1857 and 1858 diphtheria assumed the epidemic form almost simultaneously, not only in Europe and North America, but in such widely separated regions as India, China, Australia, Polynesia, and North Africa. This sudden appearance *en masse* of a disease which had disappeared, or ceased to be known excepting in rare isolated cases, produced the prevalent impression that diphtheria was a new disease. It certainly was so to the majority of the physicians who were now called upon to treat it. Notwithstanding its unusual prevalence—perhaps it ought to be said because of its unusual prevalence—among all races, and among all classes of society in every race, living under every variety of domestic conditions, the relation of diphtheria to the ruder forms of insanitary circumstance is still the subject of debate among etiologists. Speaking of this country, it does not specially follow aggregation, or haunt that core of misery which always exists in the midst of cities. Ten years ago I read a paper to this Society “On the Comparative Prevalence of Filth Diseases in Town and Country,” in which I proved that in Scotland diphtheria first

appeared in country districts, and that there it still maintained its habitat. It is so in England also. We may conceive, then, as regards our cities, of three zones of incidence of diphtheria—an outer wide encircling zone of rural districts, most affected; a middle zone, the suburbs and better residential parts of the city, less affected; and an inner zone, the centre of the city, where the poor and squalid reside, which is least of all affected. The same is true of enteric fever. The only epidemics ever seen in cities having a good water-supply originate in the country, and are regulated in the town by the freedom with which the population can afford to use country produce. This may be an element in the distribution of diphtheria also, but I apprehend that defects in those communications between the *interior* of the larger houses and the general sewers, which do not exist in small houses, have a share in it. It is worthy of note that an analogous disease is seen in fowls, and that on the Continent epidemics have frequently been found to co-exist among human beings and fowls in the country districts where the peasantry keep fowls in their houses. The average age of fatal cases of diphtheria in this country is 5·8 years. The survivors often suffer from serious lesions of the nervous system, shown by various forms of local paralysis.

Relapsing Fever is essentially a disease of the poor—of those who are either paupers or on the verge of pauperism. In epidemics its victims are recognizable, even to hospital attendants, as belonging to the flotsam and jetsam of the great ocean of urban humanity, with a uniformity which is not observed in patients admitted with any other disease. This fever was most frequently seen in the end of last century and first half of this century in Great Britain, apparently originating in and spreading from Ireland. It went with the Irish to America. In more recent years it has disappeared from Great Britain, but has prevailed in various parts of Europe, also in North Africa, in India, and China. After a clear interval of twenty years, relapsing fever was introduced into London in 1868 by Jewish emigrants from Poland, and from thence it extended to several of our larger cities, reaching Glasgow in 1870. Privation, conjoined with personal uncleanness and overcrowding, is the predisposing cause, and in urban districts where these characteristics exist, this disease spreads like wild-fire, so that if an epidemic gets headway, it is overwhelming in its proportions. The mortality is not great, but there is no disease which plunges the poor into deeper depths of helpless misery, from which they

but slowly emerge. It thus does not mend but aggravates the conditions which produce it. It leaves its victims with life, but nothing more—life so enfeebled that it can be sustained and nurtured into physical energy sufficient for self-support, only at the cost of the public.

Typhus is own brother to relapsing fever. As far into the past as authentic history permits us to penetrate, we find that it follows popular misfortune like a dark shadow. It dogs the footsteps of war, aggravates the miseries of famine, and haunts prisons and workhouses whenever authority forgets that criminals and paupers do not cease to be human beings. Typhus has, during this century, devastated all parts of Europe, and been active, though much more rarely, in Asia, in Africa, and South America; but I shall confine myself to its history in this country and North America. The habitat of typhus for English-speaking people is Ireland. It never dies out in Ireland. Thence it established itself in England and Scotland, beginning always in the western seaports, where intercourse with Ireland is most direct. It followed the stream of Irish emigration to North America and Canada. The course of the vessels in the earlier days of the exodus, before Government regulated the traffic by inspection of passengers and enforcement of marine sanitation, was marked by the corpses of those who died of this disease on the voyage. Every epidemic explosion in Ireland has been immediately followed by its echo along our shores and on the American continent. The great German epidemiologist Hirsch, to whose laborious, talented, and most interesting work I have been so much indebted, thus sums up the results of his investigations :—"It is always and everywhere the wretched conditions of living, which spring from poverty and are fostered by ignorance, laziness, and helplessness, in which typhus takes root and finds nourishment; and it is, above all, in the want of cleanliness, and in the overcrowding of dwellings that are ventilated badly, or not at all, and are tainted with corrupt effluvia of every kind. The prototype of these conditions is found in Ireland, which is the greatest sufferer from the disease; all observers agree that in them lies the true cause of typhus, unconquerable in, and inseparable from, the Irish proletariat, faithfully following the Irishman wherever he transplants himself and his misery."*

* Hirsch, *Op. cit.*, Vol. I., p. 581.

I need not tell a Glasgow audience how entirely our experience down to the present day confirms this verdict. Epidemics of typhus are now unknown, but typhus never disappears from amongst us. The houses of the Irish and Scoto-Irish and of those who have learned their habits, keep up the pedigree of typhus without interruption even for a single month. It is only at the cost of the maintenance of daily supervision and the enforcement of hospital isolation that we prevent epidemics. Every dirty overcrowded house is a potential epidemic centre. In spite of every precaution, families of cleanly citizens every now and then fall innocent victims to the license of their uncleanly neighbours. Only let the restrictive measures be suspended, and this disease, which is maintained in domestic filth and overcrowding, would involve the whole community without discrimination. The points of contact between man and man in the necessary intercourse of life in a crowded city are so numerous, and the poison of typhus is so adhesive to the persons and clothing of all who inhabit infected houses, that this would be the inevitable result. The mean age of persons attacked by typhus is about 30 years, while the mean age of those who die is 42—figures which enable us to estimate the serious social burdens created by epidemics, through time and life lost by wage-earners, with the consequent heritage of widowhood, orphanage, and pauperism.

The history of *Enteric Fever* cannot be unravelled further back than some thirty to forty years, when it began to be discriminated from other fevers. Indeed, it is only within the last few years that it has been distinguished in tropical countries from the heterogeneous mass of malarial and other febrile affections which there abound. Now, however, it is fully recognised as a cosmopolitan disease, not in the sense that it sweeps round the globe in waves, as smallpox used to do, but that it is smouldering everywhere at the same time, spurting out into irregular epidemic outbreaks, which are purely local, and present no trace of any consentaneously-acting pandemic or wide-spread influence. Everywhere it originates in faecal pollution, epidemic expansions arising when the pollution involves the water-supply or food, especially milk. Minor extensions and isolated cases, or clusters of cases, depend upon local defects in drainage and the sanitary apparatus of dwelling-houses, or arise from the home-treatment of cases where space is inadequate and the householders untidy or ignorant of the special proclivities of the disease. The mean age of persons attacked by enteric

fever is between 21 and 22 years, while the mean age of those who die is about 24. These figures are based on hospital experience, and I have no doubt, from the fact that enteric fever seizes children of the tenderest years who are not sent to hospital, that they are too high. It is the special scourge of childhood and adolescence. It pays no respect to rank or social condition. Indeed, from the fact that long exposure to vitiated local conditions acclimatizes without previous seizure, so that strangers, and those who live usually in good hygienic circumstances, are attacked when they come within the sphere of this novel influence, I should say enteric fever is most dangerous to prime lives. Murchison says, and my experience confirms his observation. "It is doubtful if previous illness increases the liability to enteric fever. *Most patients are in good health at the time of seizure.*"* On the other hand it cannot be said that the survivors are improved in health. There is no disease which strains and stresses the constitution like enteric fever. It always leaves prolonged debility and tends to develop tubercle, besides leading to many grave local lesions.

I have thus rapidly caused to pass in review before you the most important communicable diseases which infest mankind. They present interesting differences, but, speaking of them generally, I ask your attention to the following points:—

1. *The property of lateral extension.*—Given one person in a community attacked by communicable disease, and the one tends to become two, the two to become four; or, it may be, the one tends to become three, the three to become nine, and so on. In all cases you have a tendency to geometrical progression, but the ratio will vary according to the intensity of the tendency in the special disease. This tendency carries the disease from its centre of origin, as the prairie fire licks up blade after blade of grass and leaps from tree to tree with an ever-widening front. Every sick person is a menace to those who are well. The settler does not awake to his danger when the careless match is thrown down among the dry grass miles away, but it began then, not when the lurid reflection of the gathering fire lights up the horizon.

2. *The habit of endemicity* or of lurking during the intervals between epidemics in places where the conditions are peculiarly favourable to the maintenance of the disease. It may be a house in a street, or a street in a district, or a district in a city, or some

* "Treatise on Continued Fevers," 2nd Edition, p. 450.

special area in a country, or some country in a continent. It may even be one special corner in the world; but in all cases it is the permanence and intensity in the lurking place of the conditions which sustain the disease in life, which lead to the settling down of the disease in this particular place. The interest of the houses, streets, districts, and countries which have never been visited by an epidemic, or have successfully expelled it, in these endemic centres is this—that a perpetual menace of re-invasion is thus kept up. It is the same interest which the lair of the tiger has for the inhabitants of the neighbouring villages; or which the Scandinavian fiords, whence the Norsemen put out, had to the east coast of Scotland and England; or the seaports of North Africa, where lurked the Barbary pirates, to the seafarers of the Mediterranean and the English Channel.

3. *The artificial and therefore remediable nature of the local conditions which foster endemicity.*—Climate, soil, and other physical features may give those conditions greater efficiency and energy, but the conditions themselves are all essentially of the nature of uncleanness, and at most the physical peculiarities only emphasise the necessity of cleanliness. Cholera, Yellow Fever, Enteric Fever, and Typhus all positively live upon gross and palpable dirt, and wherever they sustain themselves in the endemic condition there will that dirt be found most gross and most palpable, and from thence may they be exterminated by the removal of that dirt.

4. *Even those communicable diseases, such as Smallpox, Measles, Scarlet-fever, and Whooping-cough, which can scarcely be said to live upon uncleanness, but attack man as man, are ALL aggravated thereby.* Their epidemic tendency is increased, their fatality heightened, their capacity for indiscriminate extension intensified.

5. *The soil which sustains the communicable disease in the endemic condition, and promotes the epidemic expansion, is the same which produces general unwholesomeness.* A city or a country which is noted for epidemics, and which harbours communicable diseases as endemics, is always unhealthy. The measures which will exterminate the communicable diseases will promote general health by lessening the prevalence of non-communicable diseases. In short, the adoption of radical measures for preventing epidemics covers the whole field of sanitation. The wider result follows with certainty the enterprise undertaken with the narrower aim, and cannot otherwise be attained.

6. *Whoever persists in a manner of life calculated to produce or promote communicable disease injures himself first, but next, and with certainty, his neighbour.* The lawyer's question—"And who is my neighbour?"—here rises involuntarily to our lips, and I know of no path which leads us to a wider answer to this old question than that which we have been following to-night. Who is the neighbour of the man living under the conditions of civilized life? Mr. Darwin by the same route reached this conclusion:—"Man is liable to receive from the lower animals, and to communicate to them, certain diseases, as hydrophobia, variola, the glanders, syphilis, cholera, herpes, &c.; and this fact proves the close similarity of their tissues and blood, both in minute structure and composition, far more plainly than does their comparison under the best microscope, or by the aid of the best chemical analysis."* Carlyle got a step higher through Dr. Alison's story of the "poor Irish widow," whose husband had died of typhus "in one of the lanes of Edinburgh," and who wandered about the town with her three children, seeking help, and, finding none, returned to her lane and died there, and set a-going a local epidemic which ended in the death of "seventeen other persons." He says:—"Very curious. The forlorn Irish widow applies to her fellow-creatures, as if saying, 'Behold, I am sinking, bare of help; ye must help me! I am your sister, bone of your bone, one God made us; ye must help me.' They answer, 'No, impossible; thou art no sister of ours.' But she proves her sisterhood; her typhus fever *kills* them: they actually were her brothers, though denying it! Had human creature ever to go lower for a proof?"† It certainly was low enough, but human nature requires such arguments, and the ultimate cause of the existence of communicability in disease is, I believe, to enforce the golden rule upon us in reference to the physical well-being of mankind. For "who is my neighbour" in this aspect? Not only is the Irishman in his miserable hut neighbour to Dives in Belgravia, but to the Polish Jew in his filthy "quarter;" not only the unvaccinated child of Leicester, but the unvaccinated French Canadian; not only the poor man in the slums, but the Indian ryot, who washes in the village tank and casts his dead into the sacred stream; the Mahomedan pilgrim, who drinks at Mecca the waters of the

* "Descent of Man," 2nd edition, p. 7.

† "Past and Present," Book III., chapter 2.

sacred well of Zem-Zem, which the profane chemist tells us is polluted with sewage and a main factor in the dissemination of the cholera which he carries a long stage on its journey to Europe; and the fellah of Egypt, and every inhabitant of every unsavoury town and village in Europe where the cholera encamps on its progress to Great Britain. Indeed, in these days rapid transport has so shrivelled up space, and commerce so intermingles and distributes articles of trade which may carry disease, that it is hard to say who in the wide world may not prove their affinity to me as forcibly as my next-door neighbour.

The practical question is—"What am I to do with my dirty neighbour?"—and we must bring to the solution of it a little common sense and ordinary business principles as well as philosophy. The first thing to be done is to make him a voting unit in some convenient area of local government. Let the boundary be fixed, in populous places, so that the whole continuous or contiguous inhabited area shall be one; in rural districts, so that sufficient mental area shall be secured to swamp local indifference and sustain an adequate executive machinery. Let the rates for all local purposes be raised from the same area, or somehow make it possible for any intelligent ratepayer to balance his liabilities for poor rates, police rates, water rates, public health rates, and so on, from time to time, and so satisfy himself that it pays to be cleanly and healthy. Impose upon these local administrative bodies the duty of providing the physical conditions and appliances of health, such as water-supply, sewerage, drainage, epidemic hospitals, disinfecting apparatus, &c., and of carrying out the daily operations, such as scavenging and sanitary supervision, necessary to keep the district clean outside and inside the houses of the inhabitants. To provide against the contingency of my dirty neighbours having a local majority, as well as to maintain a staff of higher capacity to advise in special emergencies and hold local inquiries, let there be at the head of the sanitary administration of the country a local government board armed with power to enforce the performance of such duties as, being neglected, first injure the locality, but next involve a risk to the general well-being of the country. The local administrative must, of course, have parallel power of prosecuting and punishing the dirty neighbour for overcrowding and other nuisances which affect the well-being of the neighbourhood. The principle to be strictly followed both in the case of the personal and the local administrative unit must

is not to do anything for them, but make them do it for themselves, and bear the expense, as they will reap the benefits. In this way a ~~constructive~~ process of education would be carried on, and a sense of personal and local responsibility be maintained. Besides, every means of directly educating the dirty neighbour should be adopted. Let our children be taught in wholesome schools, where personal cleanliness and decency should be enforced during school hours; let all learn the rudimentary facts of hygiene, and the relation of disease to pauperism, crime, and taxation.

For a mere matter of business all this requires official administrative machinery. Every business man knows that if you really wish any function implying co-operation to be properly performed, there must be executive machinery, departmental sub-division, and general supreme supervision and co-ordination. Nothing is more conspicuous than the helplessness of the individual under the conditions of civilized life to secure the physical basis of health. What can one man wedged up in a crowd do to get fresh air, pure water, more standing room, or to avoid his neighbours' disease? It is a question of personal physics, not of personal morality. There must be co-operation, with the unavoidable concomitant of sacrifice of some individual liberty. To trust to voluntary association, without legal sanction which shall coerce the unwilling minority, who have the power to undo all that the majority are doing, soon works its own cure by a *reductio ad absurdum*. There will always be stupid or wicked people, who must be coerced, not for their own sake, but to save the wise. In America, although the locust plague was estimated to entail a loss of 200 millions of dollars per annum on the Union, no single farmer or even State could effectively combat the winged enemy. Congress appointed an Entomological Commission, who drew up a scheme of national co-operation against the national plague, but they had also to take account of the dirty neighbour, and call for "State legislation to compel the indifferent and shifty members of each community to co-operate with their more careful neighbours in carrying out precautionary measures for the destruction of locust eggs or newly hatched insects."* The same has been our experience in Cyprus in combating the same insect. Purely voluntary co-operation failed. The apathetic

* *Nineteenth Century*, January, 1885. "Locusts and the Farmers of America" Miss Gordon Cumming.

peasants sometimes would not protect their own crops, to which no one would have objected if they could have starved alone.

The solidarity of human interest in the face of communicable disease has in recent times asserted itself far beyond the submerging of the individual. Nations are now learning that organisation, to be equal to the task of successfully resisting the inroads of such diseases as cholera, yellow fever, and small-pox, must embrace not only local authorities within nations, but nations themselves. Even the United States, with all its jealousy of central interference with the doings of individual States, learned from the ravages of yellow fever in the Mississippi valley in 1878 that some general co-ordination and direction was necessary for the national good; and hence the Act establishing a National Board of Health passed by Congress in the following year. Canada felt that she, being in territorial continuity, could not stand aloof, and, although as yet without legislative interference, the officials of the two countries have by conferences come to an understanding as to interchange of information and mutual assistance against the common enemies of their health and life. In Europe the same powerful agency has brought governments into negotiation. "Cholera conferences" between representatives appointed by the various governments have been held. Great Britain, under whose rule the habitats of cholera exist, has been made to feel her responsibility to all Europe. At the International Sanitary Congress which recently met in Vienna, a resolution was adopted to the effect "that an international convention between the different States be established against cholera, plague, and other communicable diseases." Certain principles were accepted as the basis of this international co-operation, among which were not merely compulsory notification of each case, concentration of intelligence of new movements of disease in a central Board sitting in some neutral State, and redistribution therefrom of disease-warnings, rules as to commerce, passengers, inspection, disinfection, &c., but stipulations as to water-supply, drainage, and other measures for the prevention of disease at its point of origin. In this way, step by step, the final end of the existence of communicable disease is being worked out. Self-interest enlists the most enlightened nations in the promotion of the physical welfare of the poorest and most wretched inhabitants of the remotest corners of the earth.

II.—*Factory Industry and Socialism.* By WILLIAM SMITH, M.A.
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[Read before the Society, 16th November, 1887.]

THE "Kapital" of Karl Marx is a book more discussed than read. General readers are content to look at the abstracts contained in Mr. Rae's or M. Laveleye's book, and finding there some sharp criticism of his theory of value, do not take the trouble of going further. But the better part of Marx's work is quite independent of this theory. It contains a history of the Factory System in England, based on Blue Books, and this part is of very great value both to historian and economist.

In the following paper I propose to show what to my mind remains true in Marx's critique.

Of his theory of Value there is not much to be said. Briefly, it is this: Labour is the measure of value. This labour must be understood as socially necessary labour: that is to say, the labour "required to produce an article under the normal conditions of production, and with the average degree of skill and intensity prevalent at the time." This labour must be embodied in a commodity whose utility is recognised by the social opinion of the time and place: labour spent on things not so recognised does not add value. Granted these conditions, articles will exchange in proportion to the quantity of labour embodied in them.

The best that can be said for this theory is, that it emphasises one side, and is, to a great extent, true of articles "reproducible at will" under the factory system. But it is quite inadequate as a sufficient law.

- I. It omits the factor of scarcity or difficulty of attainment, although that factor appears in such great classes as land and land products, minerals, goods produced under natural or artificial monopoly, &c.
- II. It fails to show how head-labour can be reduced to a common denominator with hand-labour, or skilled

with unskilled ; and also what measurable part is played by the labour that calls in great natural powers.

- III. It takes socially necessary labour as its measure, but takes no account of the masses of goods that are produced under cost ; that is to say, at wages under the decent subsistence level.
- IV. It neglects the fact of experience that, even when goods are reproducible at will, the action of supply and demand makes price oscillate now on this and now on that side of the level of labour, while many goods are permanently "cut."
- V. It takes no account of the element of time elapsing between the many processes that connect the raw material with the finished article.
- VI. It is inconsistent in putting forward labour as the sole measure of value and afterwards bringing in the *result* of that labour as a condition.

These are a few of the reasons for which the best economists, German and English, have dismissed the theory as insufficient. It might be pointed out that, as an *ideal* theory of value, as distinguished from an economic theory that must explain the facts of every-day business, it is by no means ridiculous. It is a law of our being that our capacities only grow in exercise, and that healthy congenial exercise of capacity is the best condition of happiness. But it is also the condition of the greatest conceivable social wealth that each person should get work suited to his capacities, and devote himself mainly to that. If this were possible to all, the true reward of man's life would evidently be, not in what he made, but in the life he led during his work. The best conception then of society is, where each person should realize himself in all his powers of body and mind to the utmost extent, and should throw the product of his work, thus happily conditioned, into the common purse of his community, realising himself most perfectly in giving his life-work for others. In such a community labour would be the measure of value ; for wealth would be distributed, not by results, but by the time of work that each gave. Products of equal times of work would have equal exchange value.

It is fortunate, however, that Socialism does not stand or fall with this as its economic theory of value. One may hold almost any theory of value, and yet adopt Marx's conclusion that, in the

industrial world of to-day, the large share of the reward that nature and society never refuse to labour has fallen, and must fall, to the few—the owners or disposers of capital.

It must be admitted at the outset—and it is very regrettable—that Marx nowhere, so far as I know, credits the capitalist with anything but honest stealing. If by capitalist we are to understand employer, and if our conception of the employer is that of the Captain of Industry, then it is as absurd to deny the function of the capitalist as it would be to deny a function to any other captain. But every one knows that there is an ambiguity in the word capitalist. It covers at least two distinct classes—the owners of capital and the users of capital. If then we inquire what Marx means by capitalist it may make us more just to his view.

Marx's capitalist is the ordinary manufacturer who tells you frankly that he is in business to make money. He is honest as things go. He merely wishes to have as large a business as possible, to get as good profits as he can, and to pay his workers the lowest wage they will accept. He looks on his business as his own individual concern. He has no idea of rational restrictions on profits. And, lastly, he looks on labour as a commodity, and applies to it the rule that regulates the price of other commodities—buy in the cheapest market. What is the lowest price that labour will accept? Evidently it is that determined by its cost of production; the amount of necessaries, comforts, and conveniences necessary to keep the labourer in life, and enable him to rear a family;—for the human machine wears out like other machines, and requires to have reproduced its value before it wears out altogether. So the lowest level to which wages can be reduced, as a rule, is the level of unskilled married labour. If the capitalist, then, can keep wages down to this level, he can lay hands on all that the worker makes over that consumed in reproducing his wages. If he gets three shillings a day of wages, and if he consumes three shillings in raw material and wear and tear of tools, and during the day turns out an article that sells for nine shillings, then the capitalist gets three shillings of profit. To use the Socialist language, he "exploits" the labour of the worker to the extent of three shillings, or 100 per cent. The word "exploit" is a very significant one. It conveys the double idea of using and using up; in a somewhat scientific way it suggests robbery, and so is as grateful to the revolutionary as it is

unpleasant to the capitalist. These three shillings, then, Marx calls Surplus Value; it is value produced by labour and not paid for.

The typical capitalist of Socialism, then, is the man at the head of the business, who owns the capital, and does nothing more than pay wages to managers, foremen, and men. The question immediately arises whether this is a true description of the average capitalist or not. So far as my experience goes, I would say that most large firms are composed of a number of partners, of whom one usually does the work, while the others have a position which is more or less ornamental—at least not worth what is paid for it. Emphatically, Marx's description does not apply to the organiser and working head of the business, for in the present system of industry he is absolutely indispensable. To the remaining partners, probably, Marx's description does apply. If we admit the Socialist contention that there should be a connection between wages and work, it is difficult to see why any man should get 10 per cent. simply because he is the son of his father.

I am not sure that the position of this bad capitalist, as we might call him, is different from that of the shareholder in a limited company, who draws from it what is called a dividend. The word dividend gives us no indication of whether this is considered wage, interest, or profit. So, although it seems absurd, we must ask the question: When we get a return from a manufacturing company of 10 per cent. is that interest on capital, or is it profit? Or is some of it interest and some of it profit? Can we separate interest from profit?

The fact is—interest and profit are not two funds but one. They both come out of new wealth—new wealth born of the past, added to the former wealth; just as the hundred-fold return of grain in harvest is a new wealth created out of the old seed. Wealth, in general terms, is the progressive adaptation of the environment to the wants of man, and is the product of two factors—natural forces and human labour. In modern industry these two factors are set to the work, as it were, through the mediation of capital; that is to say, the power of labour—the power that man has over nature—is enormously multiplied by capital in its shape of machinery, and as that command becomes greater, mere hand-labour plays a smaller and smaller part. Now, if new wealth is the result of nature and capital and labour working together in continually varying proportions, it is evident that we cannot, *à priori*, make an equitable division of this new wealth into three parts, and say—

one part is due to labour, and is wages ; one part is due to the use of capital, and is interest ; the remaining part is due to labour of the employer, and is profit. But, in point of fact, we do make a division.

As regards wages, there is always a standard of customary wage, varying of course from time to time and from trade to trade, and we pay according to that. Marx would say that the standard is definitely fixed, not by custom but by necessity. He asserts that wages are, as an average, never much more than enough to support the labourer in life, and maintain the average family. We shall consider this later. Meanwhile we do know that, whatever the total share that falls to the joint workers, an unskilled labourer will get no more than 18s. to 20s. a week.

As regards capital, the remuneration is also fixed. The competition of accumulating wealth and the competition of new uses for it determine a price which becomes recognised as the normal rate of interest. In general terms, it is the price that men are willing to pay rather than do without it. We take as our base line those uses of it that carry no risk, or almost none, and above that the interest rises with the risk. We say, for example, that 3 per cent. is the return for an investment as safe as Consols. We may say in the same way that 4 per cent. is a good return for property, and perhaps 7½ per cent. for an ordinary manufacturing company.

But when the returns from our investments are above that, and are not accounted for by the risk run, there is no other name for the extra return but profit. And one of the questions of Socialism is : Where does this profit come from, and whom is it paid to ? One answer may be given thus :—If interest, properly speaking, is the price that the workers are willing to pay for the use of capital, then profit is, either what the workers cannot help paying, or what they do not know they are paying. Profit, then, according to this answer, is the exploitation of the workers : and this is the answer of Socialism.

To go back for a little, let me try to put in a few words the rationale of interest. If, of two men, one works for a week to provide both with goods, and the other works the next week for both, there is an equal barter of labour, and no question of interest emerges. If, of these two men, one is strong enough to force the other to work for both, and give up a portion of the product, that is not interest : it is either slavery or robbery. If the one man lends the other a quarter of corn, and if the borrower,

having sown this corn, gets back from the ground in harvest just a quarter of corn, and no more, and returns this quantity to the lender, there can be no question of anything further as interest. On the contrary, it might be said that the worker rather deserves to be paid for having preserved the corn over a year, when otherwise it might have been consumed by rats or damp. But if such were the usual result of labour, of course there would be no borrowing.

If, however, the borrower find, as result of his harvest, that he has ten quarters of corn, is there not a claim here of the lender for something more than the return of the one quarter he lent? Assume first that, judged by the standard of the time, these nine quarters gained are no more than a just remuneration for the borrower's work. Then the lender, we shall say, has no claim to interest. If he does claim it, it will be a forcible deduction—the interest will have been taken out of the life of the worker. But suppose the result of the harvest is twenty quarters, here are ten quarters that are not due to the labour of the borrower. Has the lender still no claim? Or suppose the heavens send a harvest of a thousand-fold, does it all belong to the man who put the seed in the ground, and nothing to the man who owned the seed? In the same way, if a capitalist lend a sheep and the borrower feeds it and in due time gets the natural increase of the species in the shape of lambs, it is clear that the lambs at least are not all due to human labour, and it seems reasonable that the lender should get back something more than the sheep.

It was the exclusive looking at this aspect of the matters that led to the theory of the Physiocrats of last century. They held that all wealth came out of the ground, that labour expended on the land was the only productive labour, and that from this natural increment came interest and profit.

Now let us see if this justification of interest also applies to manufactures. In a manufacture you do not sow cotton and reap yarn, nor yet does yarn produce more yarn. As a fact, manufacture always deducts; the yarn is less than the cotton it was made from; the cloth weighs less than the yarns that compose it; whereas, as we saw in agriculture and husbandry, there is a multiplication of substance. In this respect, then, there is no natural interest in manufactures. Does it follow that any interest accruing to capital is wages stolen from labour? By no means. For what is added by manufacture is not

quantity indeed, but it is the quality of utility. Manufacture takes two products that in separation are valueless, or of little value, but simply brought together are of human use. But it does much more than this;—it takes a substance from nature, valueless, or even poisonous, as it grows, employs natural forces on it in particular ways, and produces something that was not in existence before—a new utility, a product desired by man. Now, as I have pointed out, the respective parts played in manufacture by natural forces and by human labour enter in very varying proportions into different products. It is clear, then, that the man who supplies that which gives power over nature, supplies something whose rewards are out of all proportion to the labour employed; and this is the justification of interest on capital employed in manufacture. The utility added by it is so great that there is generally enough and to spare for him who lends the tools and for the borrower who uses them.

The utility added by merchant industry is not substantially different. When one takes goods from where they are not wanted to a place where they would otherwise be wanting, the wealth added to the community is enough to pay the worker and pay interest to the one who arranges the conveyance. The productive labour of the merchant is both negative and positive;—negative, in that it prevents wealth produced from being wasted; positive, in that it allows the worker to give all his time to production.

This, then, is the rationale of interest; and I hope it makes clear that it is impossible to say, *a priori*, what part is actually due to capital as the power of superior tools over the environment. All we can say is, that some return is due, and that its proportion is determined by the relation of supply and demand.

We shall assume, then, that interest on capital is a fair and useful thing. This the Socialists allow. The question with them only is as to who shall have it. Suppose that our manufacturing company hitherto has paid a dividend of $7\frac{1}{2}$ per cent., and that, on account of the risk that such a company always presents over a public security like Consols, we may count this as no more than a fair interest. But this year it pays 10 per cent. Where does the other $2\frac{1}{2}$ per cent. come from?

If it were a private concern that was in question, the answer would be simple. A private employer working with his own capital, deserves to get on that capital, of course, the usual rate of interest without work, which we have assumed to be $7\frac{1}{2}$ per cent.

But beyond that he properly asks his own wages. Into the account of these wages he puts such items as the following :—Cost of early education and apprenticeship ; wear and tear of mind and body ; anxiety and worry ; risk, not only of losing capital and being held for debts, but of losing reputation ; cost of reproducing another race of employers as well educated as himself.

This is the justification of what is called Profit. Mill called it Wages of Superintendence : not a very good expression, but noteworthy for the acknowledgment it contains that profits are wages—that is to say, presumably, reward for work done.

Beyond these items, however, the employer does claim all that his genius or his care enables him to get out of nature over what other men working in the same field can get. Whether this is a legitimate claim or not may be questioned. In the following case it would seem vindicated :—Suppose that a farmer, from much study of the weather, sees rain coming, and puts up his stacks before they are quite dry, risking this danger against that of not getting in his crop at all ; and so saves his grain while his neighbours lose theirs. Here is an extra reward fairly earned, not at the cost of anyone. The farmer has won a profit out of nature, by the sweat, not of his brow, but of his brain.

But undoubtedly most of the extra rewards gained as profit are either got by outwitting and getting in front of other men, or by the use of inventions. As regards the former, there are immense profits made where no new wealth is produced, but old wealth transferred from pocket to pocket, or where wealth produced is appropriated by one instead of being divided among many. As regards the latter—"invention calling wealth out of the waste"—it is too well known that it is not usually to the inventor, but to the one who can make use of the invention before others, or monopolise it, that the great rewards fall ; just as the prizes of gold mining do not fall to the discoverer of the gold, but to the monopoliser of the ground.

Whether, however, we yield this extra over the wages of superintendence to the private employer or not, we at least understand the ground on which this profit is claimed by him. It is got by his special ability, and by work of one kind or another.

But in the case of a limited company earning a 10 per cent. dividend, when interest is calculated at $7\frac{1}{2}$ per cent., there is no such source of profit. The $2\frac{1}{2}$ per cent. divided among the shareholders has come out of some one's work, and is got by keeping back some one's wages.

It is *not* necessary to suppose that it is got by keeping back the ordinary worker's wages; it is more likely, on the whole, to be the wages of the manager or managers, or even, by chance, the directors. The phrase "keeping back," too, need not imply any *condemnation* of the act. If the $2\frac{1}{2}$ per cent. extra profit has been made by the exertions of the manager, the answer may very well be this: "It is a case of contract. We, the shareholders, pay the manager a fixed salary, in consideration of which he makes for us an unfixed profit. If he were in a position to guarantee us a fixed interest of $7\frac{1}{2}$ per cent., and take the risk of the profit as his remuneration, it would be a parallel case, and probably as acceptable to us."

Or if it be the unpaid wages of the managing director out of which the profit comes, he may answer in the true spirit of a Captain of Industry: "I am a salaried officer of a regiment; my duty is to do the best I can for my company; if the company succeeds under my leading I have a reward that cannot be priced in precious metal." So one may hope that, before Socialism becomes necessary, the typical capitalist will be the man who counts that, the more responsible and the more honourable his position is in the "war against bare backs," the less pay he needs; and whose conception of the proper division of rewards will be that, as it has been made by all the workers in proportions that cannot be well gauged, so it is safer for an employer to raise his wages than increase his profits.

If this is true we shall have to say that shareholders in companies earning more than what we have called interest, get all above the interest level from the unpaid labour of some one or some class. This surplus value, too, we see, may be justifiably taken on the ground of contract. But there is every reason to think that this profit is, in most cases, taken out of the earnings of those who do not know it, or cannot help it: in short, that the contract whereby the shareholders get 10 per cent. and the managers a salary, and the ordinary workers a bare living, is a one-sided contract made with helpless or ignorant men. This is the Socialist contention, and I may put it for clearness in another way.

If men are working in a field and get a certain return from that field, every honest worker is entitled to have his bare living out of it. So much, at least, without interpreting providence, we may presume from the continuance of man on the earth.

So long as nature returns no more than this there is no question either of interest or profit. But say that the heavens are bounteous and yield a surplus, the question emerges: In what shares shall this surplus be divided? The answer may be given: Part of it is due to the man who lends tools, for he has multiplied the power of human arms; and part of it is due to the man who has brought the workers from other places in due proportion, and has set the plan on which to work, who knows what kind of seed is needed and what kind of manures and labour to apply, and who, finally, finds a market for the crop.

But all the workers are necessary to the cultivation of the field, and surely if there is a surplus it is not all due to these two men. There is one factor that has been forgotten, and that is the most important one—the co-operation of nature. If nature do not give sun and rain how is any one to get anything?—for organisation and capital, after all, do little more than put natural forces in a position to work. On what principle can either capitalist or employer, or both together, claim *all* the surplus?

Evidently the division is not made according to reason, but is determined by the circumstances of competition. The history of our country has made the labourer the most helpless of all the workers, and therefore to him goes the smallest share. The accumulation of capital has made the owners of it the next helpless class, and their share is being run down generation by generation. But the scarcity of men with brains has made the employer the king of the position, and therefore he can take all the surplus if he please. To call it wages of superintendence is exceedingly misleading, in so far as the word wages usually conveys the idea of a fixed remuneration. Now every practical man knows that, while there is a level of wages for any trade, and a level of interest for various uses of capital, there is no level of profit in any trade, and there is, certainly, not a level of profit over all trades. It is impossible to speak even of a minimum profit. Farmers and landowners have for some years been working for a return below bank interest. Manufacturers have been working at less, for the reason that capital once sunk in land, buildings, or machinery, cannot be got out, and it is better to work for nothing than to lose one's capital.

But even if we grant that the employer has a right to this surplus, it is evident that it goes very often to many people besides the one or two who actually do work, and in the case of a limited

company it goes almost entirely to those who do nothing but risk their money.

To this extent Socialism has no quarrel with the workers; it is with the idlers. And if the Socialist were merely to say that law in this case should do what competition sooner or later is supposed by some economists to do—compel the profit to be returned to the world in the shape of low prices,—I am not sure that any one but the idlers would much object; and the first part of the Socialist contention is that, even granting that interest is due to capital, and wages of superintendence are due to employer, there may be, and generally is, a surplus varying in amount. If this goes to sleeping or non-working partners it goes to those who have done nothing for it, and therefore to the one class that has no claim on it.

The second part of the contention is: That in the division of the surplus, whether that surplus is divided out among capitalists and employers, or among working capitalists and idle capitalists, one thing is certain, which is that the ordinary worker does not get any share of it. Whatever the bounty of nature, whatever the power of labour, the ordinary worker gets his bare living and no more.

The argument runs thus: New value must emerge in return to labour. The earth is bountiful enough to return to man much more than the sustenance he consumes while he is working on it, and as division of labour does not emerge till this ample return is secured, it must be that the manufacturing worker produces more value than he consumes. All normal labour, then, produces surplus value. This surplus value cannot always be taken from the worker. In a new country, like America, wages are always at a comparatively high level, because the worker has access to land. If he cannot make as much in the town as he could make for himself in the country he will not work at the factory. Agricultural wages in such cases are the minimum of manufacturing wages. But in an old country, where land is scarce, and in a community where labour is organised in the most complex way, the power of capital over labour is an overwhelming one. And in an old country it seems impossible to deny that the working man's wage is never far from the level of necessary wages.

There are various ways of reading this Iron Law of wages, as Lassalle called it. Ricardo said that wages had a tendency to fall to the quantity of necessities, conveniences, and comforts that would

support, not bare life, but the life that had become essential to the worker through habit. Now it is possible, as it is in the highest degree desirable, that that level of habit should rise. So we should read the iron law in this way: Wages have a tendency to fall to the minimum standard of comfort. In proportion to the growing wealth of Great Britain, that standard of comfort to-day should admit of a two-roomed house for every worker who occupied a one-roomed house thirty years ago or so. I mean to say that as, on Mr. Giffen's calculation, wealth in Great Britain increases at the rate of 3 per cent., while population only increases at the rate of 1·3 per cent., the standard of the worker should be doubling in short periods. Is this the case with our workers? Mr. Giffen, in his two Essays of 1883 and 1886, has shown that the money wages of the working classes have risen from 50 per cent. to 100 per cent. within fifty years, while the price of commodities, as a whole, has materially decreased. This is very perplexing to those in great cities who work among the poor, and who certainly would never arrive at such a conclusion from their own observation. The solution may be found in that circumstance to which Mr. Giffen, I think, does not in these essays allude—the very great irregularity of employment. It is evidently one thing to take the rate of wages from a cashier's pay-sheets, and another to assume that the men get this wage steadily over the year. The well-known improvidence of the working classes makes a year's employment at the rate of 15s. a week a much more desirable thing than a six months' employment at 30s.

However, leaving that matter *sub judice*, and merely suggesting that the present crisis, which shows no sign of coming to an end, may have vindicated the tendency after fifty years, let us look at Marx's explanation, in which we shall probably find enough of truth without pressing his argument too far. Capitalism, he says, is not possible till the capitalist can meet in the open market what he calls the free labourer—free, that is to say, in the somewhat sarcastic sense, that he is free from all the encumbrances of property, from property in land especially. And this free labourer, instead of being in a position to sell commodities in which his labour is incorporated, must be obliged to offer for sale as a commodity that very labour power which exists only in his living self. "Now, one thing is clear, nature does produce on the one side owners of money or commodities, and on the other men possessing nothing but their own labour power. This relation has no natural

basis, neither is its social basis one that is common to all historical periods. It is clearly the result of a past historical development, the product of many economical revolutions." What is the history of this development?

Once on a time this free labourer could not have been found. In the fifteenth century, when the feudal tenures had broken up, the labourer had asserted himself as the indispensable man. The owners, left with their acres, and with no force to compel their former serfs to work for them, were not masters of the situation. The labourer had the land to go to in times when the standard of life was low, and the peasant could make by his spade almost as good a living as his former master; for before this time wealth was shown, not by variety of luxury, but by wasteful multiplication of coarse abundance.

For generations after this the land remained in the hands of those who owned it—the yeomanry. At the beginning of the eighteenth century there were 180,000 freeholders in England, according to Gregory King. It was not till the reign of Anne that the enclosures began to take the land out of the reach of the peasant. By 1760 the yeomen had practically disappeared. This was the date of the industrial revolution. The discovery of steam as a prime motor and its application to machinery found a state of matters favourable for factory industry. It found population pressing upon food, the people ground down by taxation, and the peasants in great distress. In fact, the new system found great bodies of men to whom this opening up of wage-paid industry was a true godsend. Great Britain had got divided, as it never was quite divided before, into rich men and poor men.

This is the historical origin of the free labourer. The present position, in which men and women in great towns are at the call of any capitalist who will hire them, is the natural evolution of this. The question that Marx puts, then, is: "How have the working classes remained at such a low level of wages in face of all the rush of wealth that came with factory industry?" We may object to the statement that the average working wage is at the "necessary" level, but it is impossible to deny that the accumulating wealth has been very badly distributed indeed, and that it would have been good for civilisation if the comfortable classes had had much less and the working classes much more. For answer to his question, Marx refers us to the Factory Inspectors' Reports from year to year,

and one must admit they are very ghastly reading. From these reports he seeks to prove the following points.

I.—For many years after factories were in full operation there was no attempt to fix a normal day of labour. If, then, the employer succeeded in crushing down the worker to the subsistence level, the longer the day the better for the employer. If the worker reproduced the value of his wages in six hours, and the capitalist could get him to work twelve hours, the capitalist got the surplus value made in six hours. If he could extend the working day to fourteen hours, it was two hours more of surplus value. The struggle against the compulsory regulation of the normal day was accordingly very bitter. The reports show clearly how well the mill-owners understood the value of these over-hours. Professor Senior in 1837, when the hours of labour were eleven and a half per ordinary day and nine on Saturdays, undertook to prove that the whole net profit was derived from the last hour. The act of 1850 was only carried by the aid of the landed classes, acting out of revenge for the part played by the commercial classes in abrogating the Corn Laws. Every attempt to shorten hours has been met with the most strenuous opposition and with prophecies of ruin to the country. Even now we hear the cry that our ten hours' day of work for women and youths is putting us out of the running with countries like Belgium.

II.—As law interfered to fix a normal day of labour every effort was made to reduce the cost of production of the worker himself. It is acknowledged that the capitalists, as a class, did carry the abolition of the Corn Laws. Marx attributes their action to the knowledge that cheap food meant less wages. If the worker was able to reproduce his wages by five hours of labour instead of by six hours as before, the employer could get another hour of surplus value out of him by keeping down his wage to the same subsistence level as before. Thus, he says, there has always been a well-founded opposition of interests between the landed and the capitalist class. The obvious objection here is that Marx would have to show that prices were not reduced in the same ratio as wages. There is, in fact, great reason to believe that the better part of the "surplus value" has all along gone in low prices.

III.—Another way in which the capitalist could retain the surplus value taken from him by the compulsory shortening of hours was by increasing the intensity of the labour done in these hours, "raising the productive power of the workman so as to enable him to produce more in a given time with the same expendi-

of labour." This was done in three ways—by piece-work, by the sweating system, and by the introduction of machinery. Let us take these separately:—

(a) Piece work, says Marx, comes first in the disguise of a blessing to the working man. It is a payment by results; and as it commends itself to the best class of workmen. But mark its effect on the whole body of labour. Where possible it leads to prolongation of the working day and the overstraining of energy. In all cases it raises the average of the intensity of work. The men who are strong work for ten hours at high pressure, make a great gain, and perhaps are none the worse for it. But it kills off those who are less able to stand the strain. It reflects on those who are working by time wage, and is a thorough check on them. It compels that the average of work of all kinds be brought up to the high average of the strong workman tempted by high wages. Thus, in time, it fixes the average productiveness of industry of labour, and then the wages are reduced all over—piece wages as well as time wages.

Now this looks almost like diabolical ingenuity, and to ascribe it to capitalism seems to be overdrawing the picture. But I have had in my own experience this case, for instance: where an agreement was made between a private firm and a trade-union of men working on the piece, that the workers should get all they earned at the rate of, say, 6d. for the piece, but whenever the wages of these workers came up to 35s. a week, the price of the piece was reduced to 5d. This meant, in common language, that whatever the workers added to product they should not get more than 4s. for it.

(b) What is known as the sweating system has peculiarly effective ways of evading legislation and adding to profit at the expense of wages:

1. If a woman is allowed to take things home to make up, she is removed from factory restrictions; she may work as long as she likes, and in any unsanitary conditions she likes; and she may work her children at any age.
2. By scattering the workers over a wide area and out of all knowledge of each other, the system forbids any possibility of union for mutual defence; it therefore admits the maximum of competition between the sweated workers, and puts them in unfair competition with factory workers.

3. Under it employment becomes necessarily more irregular, as no fixed capital is kept idle although the worker it unemployed.

(c) When the day of labour was shortened, says Marx, and the capitalists had prophesied the ruin of the country, they found an escape in speeding up their machinery. Spindles running at 3,000 were found to be capable of running at 6,000 revolutions and upwards a minute. Frames were packed closer, and flats made wider, so that the same worker could superintend perhaps double the number of spindles that she did before. Thus, while the product for equal times increased, an immensely greater strain was put on the energies of the workers, and wages did not perceptibly rise. Probably we shall agree with Marx when he says: "There cannot be the slightest doubt that the tendency urging capital, so soon as a prolongation of the hours of labour is once for all forbidden, to compensate itself by a systematic heightening of the intensity of labour, and to convert every improvement in machinery into a more perfect means of exhausting the workman, must soon lead to a state of things in which reduction of the hours of labour will again be inevitable."

But all this is a small matter in comparison with the possibility that machinery gives of replacing adult labour by the labour of women and children, or of replacing human labour altogether. It is impossible to deny that the most marked tendency of the present system is to replace hand labour by machinery. This requires no proving. Economists, indeed, have too long tried to smooth this away as an inevitable incident of progress; they have said, that though the introduced machine at first displaces labour, yet it cheapens production; the cheapened price of the commodity brings in larger demand; and gradually as many people perhaps are employed in making and tending the new machines as were displaced; and then the worker thrown out of employment has the advantage of buying the product he formerly made for perhaps half-price—a benefit he will appreciate if it is an article of luxury! Having said this, economists should have stopped here, but too often they went on to glorify this tendency as actually setting free a number of men to produce other articles by which the world is enriched. This would be true if the man dismissed in favour of the machine had only to go round the corner to get another job. But who does not know that the man thrown out of employment, in times like the present, will scarcely find persons to employ him?

He has to walk the weary streets till he gets accustomed to them; he has to send his wife to work and his children to beg; he loses his skill by not exercising it; he gets accustomed to eat the bitter bread of charity, and perhaps to the charm of a wandering life; and when work comes in his way, our workman has lost his most precious possessions—his independence and his self-respect. As a mere matter of national economy it would be well to bestir ourselves, to see if there is not some means of keeping our unemployed from the fatal trade of “loafing.”

IV.—The last circumstance that enables the capitalist to keep the worker down to the lowest level is the tendency to irregularity of employment, and its concomitant—the formation of an industrial reserve. Whatever the causes that produce it, we know that good times are now regularly succeeded by bad times, and one of the great problems of the day is to find out the cause of this. My own explanation is that production increases faster than demand—in this way, that we overproduce in every department before we know that there is overproduction. Then we tempt consumption by reducing prices instead of seeking the only permanent remedy of finding other branches of production that are wanted. To use a simple analogy: it is, in effect, as if we had all been living on cakes and ale so long that the producers thought they could not produce too great a supply of cakes and ale, and, having overproduced, they should try to remedy it by selling double the quantity for the same price. All the while the community would have been glad to eat meat and drink wine, but no one giving a hint of this, the bakers and brewers go on producing desperately, till the wealth of the community is embodied in cakes that go to rot, and in ale that grows sour before it is consumed. But whatever the explanation, we have times when capital is sunk in establishing new undertakings, and extending old, and when every available hand is employed, succeeded by times when men are thrown on the street, and wheels stand silent. Then it is that the workers go on the tramp in search of any work, and compete with those who are happy enough to be still in work. It is this competition of unemployed with employed that enables the capitalist to reduce his wages to the level of subsistence. One would have hoped that such a chance would not have been embraced. I have put this case to more than one employer: “If you had a gang of labourers working at 18s. a week, and found you could replace them by others who were willing to come in at 16s., would you accept the

offer!" I am sorry to say the answer I got showed that they were aware of the principles of the old political economy.

Well, this industrial reserve in our midst assumes the form of a permanent force—a continual menace to good wages. It is recruited from those who are thrown out of work by bad times; from those replaced by machinery; from those replaced by cheaper workers. It is a force that works steadily against Trades-Unions and makes union among the lower grades of labour impossible. The advantage that the capitalist gets in replacing human hands by iron ones—obedient workers that will not strike or require the consideration one must give to the human worker—is of course enormously increased by the fact that men can be replaced by women and children,—mere attention to a machine being generally unskilled labour requiring little strength. Women and children cannot protect themselves by combination. The law interferes to protect them so far on this very ground. It seems true of women's wages at any rate, that it has been possible for the capitalist to keep them down to the lowest level. But this is by no means all. In the Ricardian theory, for all its harshness, the worker's minimum wage was supposed to be enough to keep himself, his wife, and the average of four of a family. But if now the household is all set to work it becomes possible to give all six workers a collective wage, which is only the equivalent of what the head of the family was supposed to get. Thus capital gets the labour of six persons for the wage of one. "Previously," says Marx, "the workman sold his own labour, which he disposed of nominally as a free agent. Now he sells wife and child. He has become a slave-dealer." If one considers the number of households to-day, where the children are the only breadwinners, there seems some foundation for this.

The first contention, you will remember, was that too much has been going to the class that least deserved it—the non-workers. The contention I have now been explaining is, that too little has hitherto gone to those whose work is the longest and dreariest, if not the hardest. One could go much further than this, and say that hard work does not necessarily deserve the highest pay. It might reasonably be contended that congenial occupations, like the professions and trades that require varied energy, are already paid a good wage in the happy life they afford, and that the highest wages should perhaps be paid as compensation, to those whom our social system condemns to do the dirty, and unpleasant,

and least human work. Adam Smith thought that a coal miner deserved high wages, but that was in the 18th century, and the same opinion is not likely to come again before the 20th.

We now come to the much heavier arraignment of *Factory Industry* as it affects the life of the worker. And here, if I am not mistaken, there is more undoubted justification of Socialism.

Is it always good that man should be replaced by machinery?

I. It is good in so far as it cheapens commodities, and gives the consumer the benefit of low prices. Low prices are by no means the unmixed blessings they are usually assumed to be. When they come along with irregularity of employment, there is some reason to suspect a relation of cause and effect between them. We have to remember, too, that the channel of distribution of wealth to the people must be that of wages—selling labour, not buying goods. But so long as wages are steady, a general fall in prices is one of the most beneficent effects of machinery.

II. It is good in so far as machinery lightens the toilsome work of man—the work that is not good for body or soul, but work that must be done. There will always be plenty of this work if you consider, for example, how much of our modern civilisation depends on the trades of coal-mining and explosives. Anything that releases man from such work is good.

But if it be still true, as J. S. Mill said in 1848, that “it is questionable if all the mechanical inventions yet made have lightened the day’s toil of any human being,” it is evident that to some extent the liberating of wealth has meant the enslaving of man. As Emerson said, “things are in the saddle and ride mankind.” In binding the worker to a heavier life of toil in order that wealth may be produced in abundance we have forgotten the old warning,—“the life is more than meat.”

Unless a man’s business is such as he can put his whole being into, work is not an end but a means. It is an education and a discipline towards living, and, of course, indispensable to it, but it is not life itself. Man’s birthright and his end is to realise all his powers of mind and body, and to build up a character in the action and reaction of the spirit on its conditions. Anything that checks development of capacity has given a wrong direction to life, has subordinated the worker’s life to the advantage of someone else, has made man a means and not an end.

But the factory system has made true work impossible to immense classes of people. It has reduced the worker skilled all

round to the worker who is only skilled in managing a particular machine, and so has taken the first condition of art out of the man's life. It has abolished the long apprenticeships that used to make a man able to turn his hand to anything, and that at a time when it is necessary, as it never was before, that a man should be able to change his trade. It has made work, consequently, monotonous, and forced the worker to violent reaction in after hours among surroundings that make healthy recreation impossible. It has condemned the many to life in the city, among ugliness, and foul disease, and the leprosy of crime. It has taken our country lasses from the village, and tempted them to crowd into single rooms unfit for human dwelling. It has forced our factory girls to live in conditions where innocence is impossible, virtue difficult, and early marriages indispensable. Is there not some reason for the Socialist contention that our beautiful and refined life of the West-end is based upon the slavery of the East-end?—no less slavery that we call the labourer free, and give him the glorious privilege of refusing to work.

The effects of factory industry on women are not sufficiently realised by their own sex. Whatever may be our disputes about the limitation of the sphere of woman, we are all agreed, I think, that her sphere is first and foremost the house—when she has a house to look after; and that she need only look out for other spheres after she has attended to this one, or when she has no house to attend to. Whether the life of a factory girl, leaving her home before daylight and returning three or four hours before bed-time, is a good training for a housewife or not, is open to question. At any rate, there is no getting over the fact that if children are to have any chance of healthy life, mothers must bear them, and nurse them, and attend to them up through the early days of childhood at least. We are probably all agreed that mothers should only be employed in factories as a matter of mercy. Perhaps it would be a greater mercy absolutely to forbid it, as Mr. Jevons proposed, rather than that some of them should be driven to work to feed their starving children, because the current demand for work is not demand for the husband's work but for unskilled labour and cheap labour. It is a mere question of supply and demand after all. If the employers find that wives are clamouring at the mill-gates to be taken on, and will work at any wage, they will be taken on; and when men are thrown out of work it will represent itself as a kindness to take on the married women as the only breadwinners. But we

go too fast if we imagine it is only out of mercy that such women are taken on. In a speech of Lord Shaftesbury on the Ten Hours' Bill occurs this terrible passage :—" Mr. E——, a manufacturer, informed me that he gives a decided preference to married females, especially to those who have families at home dependent on them for support; they are attentive, docile—more so than unmarried females—and are compelled to use their utmost exertions to procure the necessaries of life."

And what can we say of the children's labour? Happily, the horrible things that were done by employers in the days before the present Factory Acts are impossible now. Perhaps the best education in Socialism would be the reading of the Report of the Children's Employment Commission in 1863-67. It is almost unbelievable that little things of three and four years old should have been pressed-in to work in brickfields; that children of seven should have walked twelve to fifteen miles daily carrying loads on their heads; or have lived night and day in match factories, whose very atmosphere was poison. It is as unbelievable that, only a few years ago, gangs of children and young persons of both sexes were marched round the country and herded at night promiscuously into one or two apartments. Yet these things were done; and they are written down and vouched for in the Blue Books of the British Parliament; and these wrongs were perpetrated by our fathers, who went to church and thanked God they were not as other men are, as piously as any City Bank director. And when we are told that such things are impossible now, and that the Factory Acts are old-fashioned, I hope the present generation will have these Blue Books read to them from every pulpit in the kingdom instead of morning lesson—or as a commentary perhaps on Christianity.

As I said, however, these things are meanwhile impossible, but one must fairly put the position of the children still. We persuade ourselves that to work half-time does no harm to a child, and that to work full-time does no harm to a young person after the age of thirteen and passing the Fifth Standard. Well, think of our own children of the upper classes, as we call ourselves—an expression very much to be deprecated. There is only one thing that gives a man any claim to call himself one of the upper classes, and that is the possession of the higher culture; and the higher classes, such as they are, possess this higher culture because they are able to remain at school or college to the age of sixteen, seventeen, eighteen, and twenty-one years, or even later. What education

does a child get by the time it is thirteen? It has not begun; it has scarcely laid the foundation; and its future depends on whether it goes on to build on that foundation or not. However bright the child is, it will not go on to build unless it is compelled to do so: and most assuredly it will not go far if it is working hard from six till six. Who could expect it? It seems as if we had to open our eyes very much wider and compare life in the West-end and in the East-end a little more closely. When we do, we shall probably agree with Mr. Mundella's latest utterance that we should "rather raise the age at which a child should work, protect the children, and train them physically and mentally."

So much, then, for Marx's critique. If it is not a justification of Socialism, it is at least a powerful arraignment of *laissez faire*. The next question would naturally be: What is the remedy that Marx proposes? With that, however, I have nothing to do in this paper. One thing must be said of Marx. He was no demagogue, but a quiet-loving scholar. His animus was against capitalism, not against capitalists. Throughout he took the philosophic view of the continuity of history. He looked upon the evolution of capitalist industry as an inevitable incident in progress, as humanity working out its own ends in the calm, cruel way of nature. For capitalism was the natural evolution of steam and machinery. It had to show all that was in it before it was superseded. It has done great things. It has shown how workers can live and perpetuate and multiply on half-a-crown a day. But out of this come two possibilities. Either the worker may support himself by a few hours' labour, or the capitalist may hire him, pay him his half-crown, keep him working long hours, and sell the product for 5s. This latter possibility, says Marx, has been developed first, and has shown what was in it by the accumulation of wealth in the hands of the few, and by the wreck it has made of the humble worker in Great Britain. But the very greatness of its success is bringing about its fall. The growth of wealth caused by capitalism will soon make capitalism impossible. At first it put the worker at the mercy of the capitalist; now it is putting capital within the reach of every worker. Its cruelties brought in the Factory Acts, and these Acts gave the workers leisure to combine for defence, and form the trades-unions that are gradually covering the whole field of labour. The wealth it brought made life at a very high level possible to a few, and the few coming to understand what life means to him who has fair conditions are opening their eyes to the wickedness of foul ones. Its "necessary

wage" broke up the working man's family, and sent women and children to work. By so doing it has raised the whole question of woman's sphere and woman's work, and given "a new economical foundation for a higher form of the family, and of the relations between the sexes."

Capitalism, as an historical evolution, has thus done its work positive and negative. It has given the world boundless possibilities of the perfect life, but in developing tendencies that are exclusive, and would keep this perfect life within reach of the few, it has brought us towards a higher form of industry.

There often comes a time in the career of nations when powers granted in simpler days for the common good are found to have passed into vested interests and sinecures. They are often defended, not on the ground of history and prescription, but by appeals to justice, natural laws, and so on. But when a nation awakes, it finds that, after all, the safety of the people is the supreme law, and the people sweep away the old barrier and sweep over it. If it is found that the wealth which generations of workers have handed down to us, by some historical development has got into the hands of the few who use it for themselves, it is only a question of time till the many assert their claims to it. Compulsory Socialism is perhaps not so far away as we think. If we are putting equal political power into the hands of every man, while three-fourths of these men have nothing to lose, but everything to gain, from an overturn of society, we may expect an experiment in overturn. If the majority declare for a "new divide," there is no question of right or wrong, of robbery or justice. The minority will only be able to assert their rights by might. The result would inevitably be the swing round of a democracy to a tyranny—the whiff of grape-shot on the streets, followed by the dictatorship of a Napoleon. It would be wise before that time to see if there is not something wrong with our present system, and if there is not that in Socialism that is eternally true.

The eternally-true thing is that we are all members of the human family, and that it is a family, not an anarchy of competing units; that society is an organic body, ruled by a divine purpose to a divine end; that that end, we may safely say, is the rise of all men to the highest life, the life of culture. If this culture can at present only be attained in conditions that belong to the few, it lies with the few to raise their fellows by leading them, or—to stand out of the way.

It is impossible that, in a world where the Christian idea is in

the air, the present system of distributing wealth can be thought permanent. Civilisation demands a better apportionment of work to capacity, and of wages to work.

There are two ways in which this problem, now pressing upon all thoughtful persons, may be solved. Carlyle pointed out the one way long ago, in his stirring words addressed to the Captains of Industry. They, he said, were now the only aristocracy, and to them the people must look for leading and organising. Work must be regimented, chivalried; masters and men bound together, not by cash payments only, but by honour and loyalty, with due share of the varying reward secured to all the workers. How would mere red-coated regiments, to say nothing of chivalries, fight for you, he asked, if you could discharge them on the evening of the battle, on payment of the stipulated shillings—and they you on the morning of it? All human interests in this world have at a certain stage of their development required organising, and work—the grandest of human interests—does now require it. When such time comes, to be a noble master among noble workers will again be the first ambition with some few; to be a rich master only the second; and by degrees we shall again have a society with something of heroism in it, something of heaven's blessing on it.

The other is the way of Socialism—restraints put on unlimited competition, the organisation of industry recognised as the chief function of the State. It must be remembered that we have for some time entered on State Socialism in such things as the Post Office and Telegraphs, Irish Land Bills, and so on. It is likely that the State will be asked to go much further. Practical politicians even now are considering the nationalising of great natural monopolies, as railways and banks. But of schemes of Socialism there is no end—from that of Rodbertus, who thought it would take 500 years to nationalise capital, to that of the anarchist, who thinks it could be done by making a clean sweep of the present capitalist. There is just a chance that it may be tried—and be attended with most unhappy failure—if increasing irregularity of employment makes the lot of the masses more unendurable, the flame of revolution throwing a fierce light on human suffering, and the enfranchised workers thinking that numbers are strength.

If, in the near future, we do not take Carlyle's way of it, if the idea of the responsibility of wealth and of the duty of organising labour for honour and not for reward, do not take hold of the richer classes, we shall have to prevent the revolution by leading it.

*III.—The Technical Schools (Scott's B), Act, 1857, and some of its
 Relations to Elementary and Higher Education. By HENRY
 LITTLE, C.E., M.A., Member of Council.*

[Received and read 30th November, 1887.]

IN every department of human effort the tendency of the present day is towards a scientific treatment of the subject commanding attention. Facts are collected, observations are carried on, and an attempt is made to deduce general laws and principles for future guidance. In physical and natural science, thousands of persons are to be found who devote their lives to the advancement of a small department of knowledge, but there are few who consider the conditions of the elevation of human life more important than the solution of a scientific problem. In the discussion of social and economic questions people often content themselves with the examination of details and seldom recognise that "the root of the difficulty is not so much in our methods of business, as in those in education, in the broadest sense of the term. Production is at fault, but it is the production of human beings. The fundamental wrong is in allowing large classes of people to grow up with so poor an education, physical, mental, and moral, that they are unfit for intelligent and energetic work." * Recently we have heard a great deal about the necessity for improved Technical Education as a remedy for many of the evils from which society is at present suffering, but almost every speaker or writer seems to look at the subject only from his own point of view, and fails to see that this part of education "is most difficult to treat, except in relation to the general educational system, and that what is wanted is a general and statesmanlike attempt to organise the whole of the middle-class education of the country." † In the following remarks on the Technical Schools Act and some of its relations to elementary and higher education, I will endeavour to keep some of its wider bearings in view, and will not enter on the

* Professor A. Marshall, "Industrial Peace," p. xxv.

† *Times* Leading Article.

discussion of details of methods or arrangements, as these must vary considerably according to the requirements of different localities.

In no department of legislation have we more right to expect a scientific treatment of the subject under discussion than that relating to education; but when we review the history of educational legislative enactments, especially during the last thirty years or so, we are struck, not only with the way in which the fundamental ideas which underlie all education have been ignored, and with the absence of scientific methods, but also with the persistent demands of Government departments for methods which are unphilosophic and unscientific. Before the days of codes and syllabuses there may have been, and doubtless there was, a great deal of very inefficient teaching, but at the same time there was at least freedom for a good teacher impressing his individuality on his pupils and imbuing them with his love of learning. Now, however, all is changed, and a great part of the work of education is entirely a matter of statistics. The teachers are compelled to study the idiosyncracies of examiners and the peculiarities of codes and syllabuses, and they are not free to assist in the mental and moral development of their pupils in the best manner possible. The system of what is called "payment by results," and which exists in no other country in the world besides Britain, was introduced by a statesman who despised everything which could not be measured by a foot-rule, and estimated in pounds, shillings, and pence; and it could only have been continued in a country, so long as it has been in this, where commercial methods of looking at things have obscured the judgment in higher matters. Since its introduction every true teacher has protested against the system, and I have never heard of any one deserving the name of educationist or statesman who defended it on any other ground than that of convenience. No reasonable man would object to payment by results if it were possible to measure the results, but in education the attempt is made to measure the immeasurable. The man who makes passes to the extent of 99·9 per cent. may be, and very likely is, a less conscientious teacher than he who only gets 90 per cent., for education is not to be measured by a mechanical knowledge of the three Rs, nor by any number of passes in specific subjects, or in those of the South Kensington or any other syllabus. It is not simply a process of pumping information into the students, it is, as I have pointed out, a drawing out of their

powers, a development of their mental faculties, of their physical constitutions, and their moral natures. How the amount of this development is to be measured, at least in such a way as to give a basis for the teacher's salary, I have never heard any man attempt to explain.

It is not my intention at present to enter into a detailed criticism of our educational methods, but there is one other point which must not be omitted, and that is the effects of those methods on the health of the scholars. A committee has been investigating this subject in Manchester, and in its report I find the following sentence:—"As a result of the discussion that has taken place during the past few years on the question of over-pressure of school children, and the special inquiries arising out of it, an amount of suffering on the part of the children, previously unsuspected, has been revealed." There can be little doubt that the amount of over-pressure now existing is having a disastrous effect in many cases, and scholars leave school with all the energy washed out of them, and with an intense disgust to everything in the way of study, and they drift along, listless members of society.

The following extract from a leading article in the *Scotsman* gives sound advice regarding our present educational position:—

"In ordinary circumstances it would be unnecessary at this early date to remind the public that the triennial School Board elections take place in April next. But the circumstances will this time be exceptional. A new question will have to be dealt with—almost, if not quite, the most important question that has come up since the Boards got fairly into working operation; and it is time that intending candidates and the ratepayers generally were beginning to have ideas on the subject. The Technical Schools (Scotland) Act will come into effect as soon as the elections have taken place, and it will be the duty of the new Boards, under the guidance of the Scottish Education Department, to organise and put in operation the new system of instruction which, it is hoped, will then be established. First of all, however, the ratepayers will have to discharge the responsibility of determining whether they will have technical schools or not. There has been a long-continued and apparently earnest cry for technical education. Now we have got the Act, the new School Boards will have the power of carrying out any mandate on the subject which they may receive from the ratepayers. Without a mandate they may do nothing, however, for the Act is permissive. It does not attempt to force technical schools on unwilling ratepayers. It takes for granted that the cry for such schools was sincere, and it simply gives to the ratepayers the power, through the Boards, to establish them wherever they are wanted. Here, then, is the first question which the ratepayers in every parish and burgh must determine for themselves between this and April. Now that they

have got the Act, will they have the schools, or will they refuse to establish them? The great body of ratepayers will have to consider and decide this question; but in this, as in most matters of public interest, the decision will be greatly influenced by local leaders of opinion. A grave duty and responsibility will rest upon educationists and all public-spirited persons who have given attention to this question, and understand the need there is for technical training, if this country is to retain its ancient pre-eminence in manufactures, in the industrial arts, and in commercial enterprise. They must educate the ratepayers. It is time that they were setting about the work. It might be a fatal mistake to assume too easily that the ratepayers generally will be eager to start technical schools, or that there will be no serious opposition. For the national credit it is to be hoped there will not be serious opposition. A more patriotic work could hardly be undertaken than the one proposed. The establishment of a good system of technical education will be of more value to Scotland than any, perhaps, of the political measures which are under discussion. Still there may be opposition, and as technical schools cannot be had for nothing, there may be resolute opposition from all the class of penny wise and pound foolish philosophers. A haphazard policy may, however, be more foolish and wasteful than injudicious niggardliness, and it will be the duty of those who work for the establishment of technical schools to consider well beforehand how the schools are to be carried on, and how they are to be supported, so that they may be able to satisfy the ratepayers that it is not an expensive luxury that is proposed. The ratepayers will be justified in demanding assurances on this point."

My object in bringing the Technical Schools Act before the notice of this Society is chiefly for the purpose of inviting the co-operation of the members in assisting to guide public opinion in the proper direction, for I agree with what is expressed in the foregoing extract, that a grave duty and responsibility rest upon all public-spirited persons who have given attention not only to educational, but also to more general social questions, for it is as absurd to separate education from social and political economy as it is to separate those from ethics. We ought to do all in our power to impress upon our legislators, as well as upon the local authorities who are entrusted with executive powers, that the best constitution of society is that which, while aiming at the greatest good of the greatest number, interferes as little as possible with the development of the individual.

It follows from what I have said that a system of national education should be founded on some theory of the province of Government, and the proper limits of interference in the affairs of the people. We may, for all practical purposes, leave out of account the opinions of the believers in the extreme doctrines of *laissez-faire*, which would exclude the interference of the State alto-

production and consumption of money, without regard to the consequences involved, then the sooner we discard political economy, at least as a guide for legislation, the better. The object of the statesman should be to assist in bringing about conditions favourable to the production of a healthy, virtuous, self-dependent, and, therefore, happy people; and anything which interferes with that object should be ruthlessly pushed aside, whether it be contrary to the regulations of a Government department or the so-called principles of political economy.

The Technical Schools Act is a specimen of patch-work legislation, resulting from a partial view of a much wider subject than that covered by the Act. There can be no doubt that a great part of the cry for improved technical education has been made by men who had a very indistinct idea of what they wanted; and now that we have got a Technical Schools Act, I have not met two persons who have the same notions as to what is to be done under the powers it confers. Personally, I think that practically nothing will be done, for some time at least, beyond possibly a slight extension of what is already in operation, the Act being permissive, and the great body of the people being of opinion that if the money already raised were more judiciously spent it would be sufficient to meet the wants of the case. The Chancellor of the Exchequer evidently shares in this opinion, for in the discussion in the House of Commons on the English Technical Schools Bill, when endeavouring to allay the fears of those who dreaded increased taxation, he tried to show that only 4,000 boys a year could take advantage of its provisions. If this assumption be correct, a simple calculation by rule of three gives a very small number of probable scholars for Scotland. In fact, they might all be accommodated in one of the smaller Board Schools of Glasgow. I further think, however, that it is a mistake to have a special Technical Schools Act. If we reorganised our educational arrangements, and had the three grades of schools which are universally recognised as necessary in the national system—namely, elementary, secondary, and higher, and had properly constituted authorities for superintending and assisting these when necessary, there would be no necessity for ticketing the various schools, and passing special Acts of Parliament to regulate their management. As in a modern university all departments of learning should be encouraged and developed, so the system of modern secondary schools for any district should have departments, either

in the same or separate buildings, which would lead up to the university, or at least give a fair education to all classes of students, many of whom would not proceed to the university. There is no necessity, however, for attempting to mould all these institutions, even when of the same type, to exactly the same pattern. As much freedom as possible should be given to their managers and teachers, so that individuality and originality may be encouraged as much as possible, the central authority merely exercising sufficient control to prevent extravagance or waste of energy through unnecessary competition. There is considerable difference of opinion as to the proper bodies to which the management of secondary schools should be committed. I am inclined to agree with Lord Elgin, when in his recent address in Glasgow he proposed that these bodies should be representative of the whole county, and not simply of School Board districts. The secondary schools, whether for classical, commercial, scientific, or technical education, would be planted in those districts where they were required, and receive such assistance as was absolutely necessary. There are no reasons, however, why secondary education should not be to a large extent self-supporting, and the assistance given should not be so much in the way of direct endowment as in the supply of bursaries to bring up the best scholars from the elementary schools. Direct endowments too often induce their holders to take life easily, and, except in the case of men of recognised power and ability, they ought to be avoided.

The elementary schools would, I suppose, continue to be managed by the School Boards as at present; but the work done in them during the day should, for the most part, be confined to that part of education which is compulsory, although in the evening classes the subjects of a general education should be continued into some of the higher departments. In large towns and populous districts this arrangement could be strictly carried out, but in country districts it would be necessary that the teachers should give the elements of some of the higher subjects in the day classes, as the old parish teachers used to do. At present, and especially in large towns, every teacher of an elementary school is ambitious of making his school an academy, and this I believe to be the real reason why matters have drifted into their present position, in the absence of a definite policy on the part of the School Boards. The ambition is very natural and should be guided, not extinguished; for while I would classify the schools

into their different grades. I would make no such distinction among the teachers. The standard of their teaching should be as high as possible, and every encouragement given for the most distinguished among them passing from the elementary to the secondary, and even to the college or university grade. We should also make arrangements for the promotion of a few of the best scholars from the lowest to the highest grades of educational institutions. The School Boards should institute small bursaries of from £5 to £10 a-year to take the most promising scholars from the elementary to the secondary schools, while in each parish in the West of Scotland there ought to be at least two bursaries to lead to the university, the technical college, or some other higher institution. We would thus give opportunities to those who were likely to do any good in such institutions to reach the highest positions, while at the same time we would not encourage men who would make good journeymen to become inefficient ministers or unsuccessful doctors, nor tempt those who would be good tradesmen to aim at becoming leaders of industry and cause them to end in the bankruptcy court. Our system of elementary education tends to make the scholars become clerks and starve on a miserable pittance, rather than sell their hands by manual work; and if we do not take care, our technical education will turn out by the worse men who think themselves qualified to be managers, and by the hundred those who are willing to be draughtsmen, or to follow any genteel occupation, but who would never dream of working with the hammer and chisel. In short, we want a different ideal as to the object of education from what is usually kept in view—not merely to get on, or make money, or follow a genteel occupation, but to dignify our work, whatever it may be, and, in addition, worthily to act our part as citizens should be our aim.

The management of the universities and of the colleges associated with them would, of course, be vested in the University Courts, which should include representatives from the local colleges. One of the duties of these courts would be the maintenance of a proper standard for admission to the classes; and in the last Universities Bill, chiefly in response to the demand of all educationists who took an interest in the subject, the Commissioners to be appointed under the Act had their attention specially directed to the institution of an examination, either on entering the university, or as a preliminary condition of entering on the

course of study for a degree in any faculty, or of both such examinations. The University of Glasgow has recently instituted an entrance examination for students under seventeen years of age, and those who fail to pass it, while they are permitted to attend any of the classes in the curriculum of arts for purposes of instruction, such attendance does not qualify for graduation, nor entitle a student to receive a public certificate of attendance. The examination is conducted by two special examiners, acting in conjunction with the professors in the faculty of arts. I cannot express an opinion on this examination, as I have had no opportunities of judging of it, but I think the following sentences by Professor Chrystal, of Edinburgh University, are well worthy of consideration. Speaking of a leaving examination for secondary schools, he says:—"Perhaps the most important object of a leaving examination is to set a minimum standard for the highest work of the secondary schools, and to mark to some extent the boundary between their province and that of the universities. This standard must be so high as not to discourage progress in our best-equipped schools, and yet not so high as to snuff out the too many schools in Scotland that are as yet inadequately equipped to meet modern requirements. Some have thought that an entrance examination conducted at the universities would better answer the above object. My experience has taught me another lesson. I believe that the force of circumstances would speedily lower the standard in any university examination, not merely to the level of our poorest secondary schools, but lower still—namely, to the level of the teaching of special subjects in the primary schools, many of which are at present actually doing the work of secondary schools in large towns, where, if our educational machinery were properly co-ordinated, there is no need for them to undertake any such function. To stereotype by official sanction any such standard for university entrants would be disastrous, not only for secondary schools properly so called, but, in the end, for the universities themselves."* In my opinion such an examination as is indicated in these sentences should be under the control of a body not directly interested in the pecuniary success either of the secondary schools or of the universities, but which had a general interest in both, and such a body is to be found in the Scotch Education Department; and I trust that the leaving examination for

* "Report on Scotch Education," 1886-87, p. 119.

secondary schools will soon become a permanent institution. This examination should be such that an average boy of sixteen who has gone through a regular course should have no difficulty in passing it, and there should be considerable latitude given to the scholars in the choice of the subjects. Under universities I include, of course, colleges for applied science, or technical colleges, as they are usually called, as these are destined to be important parts of the universities of the future. When we are within sight of a reasonable settlement of the question as regards the older branches of learning we must take care that no conditions are made which impede the progress of the newer.

Not only should our educational system have been rearranged before the Technical Schools Act was passed, or even included in a more general measure, but the subject of what is usually called "free education" should have been carefully considered. A great many of the Scotch Members of Parliament are in favour of free education, and in so far as education is compulsory I would support the proposal that no fees be charged. This may seem a violation of the proviso I made about State intervention, but, as I have said, all such matters should be decided by an appeal to the concrete conditions of human life. I cannot enter into a full discussion of this subject, but while recognising that it would be highly desirable, if it were possible, that each parent should contribute directly to the expense of his children's education, so that individual responsibility might be increased, when we remember that a large part of all the expenses of children attending Board Schools is already paid by grants from the Imperial Treasury, that a great part of the time of the teachers is taken up with the collection of fees and the statistics connected therewith, that it is only the most worthless of parents who get the fees remitted, while the honest and independent pinch themselves and their children rather than receive the pauper's brand; in short, when we put the disadvantages against the advantages of the present system, I have no hesitation in saying that the former outweigh the latter. This opinion is now being reached by many men who study educational questions, and some of the politicians who take a special interest in such questions, who a few years ago opposed free education, are now strongly in favour of it. The late Professor Hodgson, in one of his letters, said—"I need scarcely say that I go heartily with you in refusing to hold poor children responsible for their parents' vices, and to allow them to suffer on

that account *more than is inevitable*. Let us all do our best, and still their suffering will be only too severe. But the real question is—What is the *interest* of society in this matter? With that I believe that social *duty* exactly coincides." To another correspondent he wrote—"By the abolition of fees a vast amount of trouble and complication is saved, while compulsory attendance is vastly facilitated. There is no more charity in the matter than in the supply of water or gas to a town. Every one pays for water according to his means, and all share in the common benefit. Gas-light in the streets, or protection by the police, is not of more common interest than is the supply of schooling to the children of the community. The fees now cover but a small part of the total cost, and the balance of advantages seems to me strongly against them. The grand aim must be to make schooling absolutely universal, and to sweep away the notion that the benefits of instruction are obtained only by the individuals subject thereto. It is your interest and mine that all should be taught, and not merely our own children."

If fees were abolished for that part of education which is compulsory the schools would, of course, be as free to the rich as to the poor; but if social pride, caste feeling, or religious belief prevented any one from taking advantage of them, he would be at perfect liberty to send his children to a voluntary school, if that were open to proper inspection. As a matter of fact, the social difficulty would not intervene to any great extent, at least in towns, because these might be mapped out into school districts, and the children of those districts would have the first claim to admission, and the social position of the scholars would be simply that of the district in which they lived. The present system of grading the schools by means of the fees is altogether wrong in principle; the State should not accentuate and perpetuate caste feeling, although if free schools be adopted it will be bound to give the same facilities to all classes for obtaining a good elementary education within a short distance of their places of residence. At present it is not so much education as a special kind of school which is compulsory. The well-to-do may, in the event of free education becoming law, be required to pay a little more than they do at present, but that would simply be a further recognition of the fact that members of society are bound to contribute to the general good. Classes which accepted the Elementary Education Act, and the Act for abolishing toll-

bars, which placed the whole charges involved on the rates, and relieved them of considerable payments, need not grumble if the same principle be extended to other matters which are not so much directly to their benefit.

School Board action has drifted far beyond what the promoters of the first Education Act ever intended, and far beyond what should ever have been allowed. It has violated the principle which I have mentioned as that which should limit State interference—namely, that that interference should only take place for the purpose of enabling individuals to help themselves and draw out their best energies. In Scotland it has to a large extent extinguished voluntary effort, and no doubt it has almost crushed out all intention on the part of the wealthy to bequeath money for elementary education; and, combined with the action of the code, it has tended to mould the youth of the country to a uniform Government pattern. All this, or at least a great part of it, might have been avoided and much money saved to the ratepayers, if voluntary effort had been supplemented, instead of being crushed out. No doubt it will be said that many of the voluntary schools were bad. That may be admitted, without however admitting the wisdom of extinguishing them. They ought to have been improved, and placed under conditions in which it was possible for them to continue to improve. If the State insists on a certain minimum of education in certain subjects, it has a further right to insist on all the teachers being properly qualified, and the buildings employed for school purposes being of a suitable nature, and for the schools being open to public inspection. If these conditions be satisfied, then, so far as a share of the rates or Imperial grants is concerned, these schools ought to be treated in the same manner as the Board Schools. This proposal will at once suggest the religious difficulty, but it seems to me, if people will put themselves to the expense of building schools, and if they satisfy the conditions laid down by the State for secular education, the State has no right to interfere further. We sometimes hear it said that in Scotland the religious difficulty has been solved; as a matter of fact, it has been shunted; and like all social problems which are not fairly faced, it will reappear when the consequences of the action which has been taken have had time to make themselves felt. During a recent visit which I paid to England nothing struck me more forcibly than the great growth of the opinion that there was more in education than was dreamt of in the philosophy of School

Boards, an opinion which is greatly strengthened by the latest report of the Education Commissioners. I found, moreover, a very strong impression among merchants and engineers that although young men now came to them with bundles of certificates, they were largely wanting in the power of applying their knowledge and in originality. They thought and acted according to the rules of a Government Department or the text-books of their examiners or teachers. What men who really think for themselves complain of is that a great deal of what is called scientific or technical education is often more formal than the old classical education, and it will neither make better individual men, nor improve society as a whole. Science shows us that development proceeds from the homogeneous to the heterogeneous. Our educational methods try to reverse this and tend to produce uniformity among the scholars. They give supremacy to the mediocre natures, which, of course, are the most numerous and pay best; they suppress genius, and level all down to the commonplace.*

After this somewhat lengthy, although necessary introduction, we may now examine the provisions of the Technical Schools Act in order to see if we can extract their meaning and ascertain what use can be made of them. Although a complete reorganisation of education is highly desirable, vested interest (that great enemy of progress), class prejudices, ignorance, and apathy are likely to prevent a solution of the problem in anything like a systematic manner; and instead of deliberately choosing the right method we are likely to blunder into it after a series of expensive mistakes. It is necessary, therefore, to understand as clearly as we can what is the object of the Act, and how far it can be made to aid in the development of education in the proper direc-

* Events and public opinion move very rapidly at the present time. Since the above was written I see that the National Union of Elementary Teachers has formulated proposals not only for getting rid of the system of payment by results, but also for utilising voluntary schools in the manner I have suggested. Moreover, Lord Randolph Churchill has, within the past few days, declared in favour of free education, and he would allow parents to choose whether their children should be educated at voluntary or Board Schools, these, of course, being under the same conditions as regards payments of grants or share of rates. His lordship is sometimes careless about facts, but he deserves credit for his ability, and courage in forming opinions of his own and daring to express them; and when we find him in accord with extreme members on the opposite side of the House of Commons on any question, it may be taken for granted that that question is very nearly ripe for settlement.

tion. A Scotch Member of Parliament, in writing to the newspapers a short time ago, said he was of opinion that the Act was not only premature, but also bad. As, however, he thought that the people of Scotland wished to have it passed he did not oppose it, and he left it to those who would benefit or suffer by it to judge whether they would adopt it or not. This, to say the least of it, was not a very worthy part to be acted by a man who ought to have led public opinion. But it represents fairly well the state of that opinion. There is an indefinite idea abroad that something ought to be done, but what that is few have taken the trouble to think out for themselves.

If we turn to the Act itself we do not get very much information which is likely to help us in deciding on a course of action. We are told that "the expression technical instruction" means instruction in the subjects approved by the Scottish Education Department, and in the branches of science and art, with respect to which grants for the time being are made by the Department of Science and Art, or in any other subject which may for the time being be sanctioned by the Department. The definition of "technical instruction" is sufficiently vague to include anything whatever which is an advantage, but it is difficult to see what the approval or disapproval of the Scotch Education Department has to do with making a subject a branch of technical instruction. I suppose it means that the approval of the Department must be obtained before any subject is recognised as forming part of the curriculum of a school. This, no doubt, is a very reasonable condition if it be exercised in a reasonable manner, for all sorts of eccentric notions would be carried out unless there were some central controlling power; but if the Scotch Education Department attempts to arrogate to itself the dictation of the subjects to be taught in the different parts of the country, and the methods of teaching them, that must be resisted, and the people of the district allowed a large amount of freedom in their selection. I will not discuss the dual administration of the Scotch Education Department and the Science and Art Department, but Lord Lingen, who has had long experience of such matters, in a discussion in the House of Lords pointed out that difficulties are certain to arise. The point which I wish to emphasise now is that the decision as to what constitutes technical education is likely to a large extent to be thrown on the people of the districts where the Act is applied, and, as the most indefinite notions exist on the

education' may be understood; not that education shall be made subservient to industrial success, but that the acquisition of industrial skill shall be a means of promoting the general education of the pupil; that the education of the hand shall be a means of more completely and more efficaciously educating the brain. It is in this latter sense, in which labour is regarded as a means of mental development, that 'industrial education' is understood by the most enlightened of its advocates. They are well aware that to introduce a trade into the school is to degrade the school; that to take away from the young the time that should be dedicated to the elements of general culture, and devote it to training them in a special aptitude, however useful later on, is to impair the humanity of the child. They desire nothing of this sort, and they ask that a workshop be connected with every school for no other reason than that for which a chemical laboratory is connected with every college. There are thus, two antagonistic parties whose watchword 'industrial education' has alike become. The one seeks to make the mass of mankind more machine-like than they really are, though with the proviso that they shall be made more perfect machines, more skilful to increase wealth, and to feed the channels of the manufacturer's profits. The other party, standing at the opposite pole of thought, seeks rather to elevate the masses, to more completely develop the humanity of the young, and looks upon technical and art education in the school as a novel and admirable means for achieving this result." This latter party is the one which is likely to receive the support of all who have studied the subject in its wider bearings. The remarks of the Secretary for Scotland, when introducing the Bill into the House of Lords, might in the hands of an enthusiastic School Board be taken as sufficient to justify the inauguration of an extensive system of apprenticeship schools. He said that "it was impossible to forecast the advantages which a Bill of this kind might produce. It would probably put a final stop to the system of apprenticeship, but the system was already dying out, and it was in consequence of that fact that this Bill had been found necessary in order to supply the thorough training which the apprenticeship system was calculated to give." In former times the tradesmen and manufacturers were at the trouble and expense of training their own apprentices. Some now seem to think that a system of technical education should relieve them of all this. I do not

mean to say that the time may not come when such charges may be borne by the country generally, instead of by the parties specially interested, but I do think we are still a considerable distance from that time, and therefore all attempts at the direct teaching of trades at the expense of the rates, or even by imperial grants, should be discouraged. State-supported technical instruction should simply mean, general instruction in the principles of applied science and art, and special instruction in the applications of these principles to particular professions or trades. This instruction should be a necessary part of the training of every apprentice, and no journeyman should be recognised who had not combined with his practical training a certain minimum amount of it, while in the higher departments the diploma of a technical college should be insisted upon. In some special departments trades schools may be necessary, but these should either be self-supporting, or receive whatever pecuniary assistance they required from those specially interested in them.

I might quote the opinions of many men who have studied the subject, in support of the views I have expressed, but time will only allow me to mention a few. The late Professor Fleeming Jenkin said—"If you mean by technical education, attempting to teach a man his business by a college course, I think it is a very mischievous delusion indeed; but if you mean that in addition to his practical training you would give him some theoretical training, some technical courses, I think it would be very useful indeed." Professor Huxley says—"I do not think that much good is to be done by attempting to deal with the trades directly in the scientific education of the masses of the people. The great object appears to me to be to construct such a scheme as should enable you to sift out and get hold of the men who have really scientific ability; give them a fair scientific training, and you may trust to the arts getting all they want out of them." When the Council of the City and Guilds of London Institute were arranging their course of instruction, they consulted a committee of gentlemen who were well qualified to advise on the subject, and these were unanimously of opinion:—(1) That the teaching of the practical part of the particular trade or manufacture should not be carried out in certain establishments auxiliary to those devoted to theoretical instruction, and conveniently given in connection therewith. (2) That the practical part should be left to be acquired, in workshops and manufactories, by means of apprentice-

ship or otherwise. (3) That the function of the teacher should be confined to instruction in the various arts and sciences connected with industrial undertakings, and especially on their practical application. These views have been concurred in by the Presidents of the Royal Society, the Chemical Society, the Institution of Civil Engineers, and by other persons well qualified to judge.

The administration of the Technical Schools Act is entrusted to the School Boards, and, from the standard which is to be exacted from the scholars, it is evident that the instruction intended to be given is what would usually be called secondary. If, therefore, elementary education is to be improved, it must be by some means altogether independent of this Act, so that in the meantime we need not discuss this aspect of the question, although I may say that it is altogether a mistake to attempt to draw a distinct line between technical and general education, the two should go on simultaneously from the day the scholar enters school till the day he leaves it. As I have suggested that all secondary education should be placed under the control of Boards having charge of wider areas than School Board areas, such as counties, so that the various interests might be harmonised, and taxation equalised, my next objection to the Act is that its working is entrusted to bodies whose jurisdiction is too limited. The power under the Act whereby any two or more School Boards *may* combine together for the purpose of maintaining a technical school common to the districts of such School Boards would remain practically a dead letter. The *may* will require to be converted into *must*, if the provision is to be of much use, as such joint arrangements are too complicated ever to be taken advantage of to any extent. Elementary education is approximately the same in all parts of the country; but secondary education, especially that part of it which is of a technical nature, must be given in localities which are centres of industry, to which pupils from all parts of the country would flock; and it would be unfair to make those localities pay heavily for what was benefiting the whole country. If the county were taken as the basis of representation and local taxation, the injustice would to a large extent be removed, while the Imperial grants would represent the advantage to the country in general, arising from the improved system of education. The County Boards would not necessarily be dissociated altogether from the School Boards. These latter ought to be asked to send representatives, who, along with

the others elected or appointed in other ways, would be better able to do justice to secondary education in all its aspects than ordinary School Boards could possibly be. We may assume that all the members of these Boards know something about elementary education, but we may safely say that few of them know much about technical education. The present method of constituting such Boards prevents many men who have thought deeply on educational matters from wishing to enter them. The worry of contested elections is alone sufficient to damp the enthusiasm of many who would otherwise be glad to assist in managing the educational arrangements of the country, while the time which is occupied by School Board work, by those who attempt to do their share of it in a conscientious manner, in large cities at least, practically renders the position untenable except by those whose time is altogether at their own disposal. So long as School Boards have the power of taxation, so long must their members be elected by public vote, but there is a provision in the Elementary Education Act which in Scotland is seldom, if ever, taken advantage of. They have the power to commit the management of any school under their charge, and to delegate any of their powers under the Act, except the power of raising money, to managers appointed by them. The public spirit of the country ought to be developed by the School Boards inviting men who are known to take a general interest in educational matters, or who are specially acquainted with certain departments, to act as managers of the schools in their neighbourhood. Such managers, or Local Committees—call them what you like—would be capable of regulating the instruction afforded according to the demands and requirements of the districts in which the schools are established. In large cities, with, say, fifteen members in the Board, even supposing they all took a fair share of the work (which is a very charitable supposition), it is physically impossible for them to attend to all the matters requiring their supervision; and the consequence is that the work and policy of the Board fall largely into the hands of the permanent officials and of the teachers, and become in great part matters of statistics and book-keeping, for the official mind dearly loves order, and glories in percentages. If this be true of elementary education, what, I ask, would happen if the Boards had charge of technical education? The sixth clause of the Technical Schools Act stipulates that "every school provided under this Act shall, in respect to all subjects, other than those for

which a grant is claimed from the Science and Art Department, be conducted in accordance with the conditions which may from time to time be set forth in the Scotch Education Code annually laid before Parliament under the heading 'Technical Schools.' When every conscientious teacher in the land is demanding the abolition of the Code for elementary education, here we have thrust upon us a new Code for technical education, with all its attendant evils.

Not only, however, are School Boards to have the management of technical schools started by themselves, but they have the power to effect the transference of existing technical schools to their authority. Whether the individual members of the School Boards wish it or not, the inevitable result of this provision will be the almost total extinction of voluntary schools. These individual members have continually protested that it was their wish to encourage voluntary elementary schools, but notwithstanding, their united action has been such as to nearly extinguish those schools in Scotland, as they have allowed themselves to drift along without distinct aims. Lord Balfour of Burleigh in his recent speech in Glasgow naturally showed that he felt himself aggrieved by this provision of the Act, after having spent five years in reconstituting the most important of the existing technical schools. He pointed out, however, that although the Act gave power to transfer the schools to the School Boards, it gave no power to transfer the endowments, and he asked if it was a reasonable proposal to transfer the schools to the School Boards, and leave the endowments in the hands of the governing bodies. The powers of the School Boards under the Technical Schools Act are very similar to those they have under the Elementary Education Act, and the results are likely to be similar. I have been assured both by the Chairman of the Glasgow School Board and the Convener of the Evening Class Committee, that they have no wish to enter into competition with existing institutions. If all the members of School Boards were men like Sir John N. Cuthbertson and Mr. Kerr, they might safely be trusted to do their best for the community, without the aid of any special Acts of Parliament; but they are not, and unless a definite policy is drawn out for their guidance, the majority will simply drift along in the direction in which their most active members, or their permanent officials, are individually inclined.

It is not necessary to consider in detail all the other clauses of the Act, as they, for the most part, relate to matters of routine,
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those which I have touched upon being the most essential. Lord Balfour, in the speech I have mentioned, said he would like to see School Boards, or some other local authority, empowered to put on a very small limited rate, such as, for example, was put on for public libraries, and out of that rate, he did not mean that they should necessarily have a school of their own, but that terms should be agreed to between them and the owners of existing schools to subsidise those schools, and to have a certain share in their management. He added that he did not know whether that would be considered a revolutionary proposal, but he thought it was the most economical way in which the people of this country could frame a satisfactory system of higher or technical education. This proposal is exactly in terms of an amendment to the Technical Schools Bill, which was submitted to the Government by the Governors of the Glasgow and West of Scotland Technical College, and to that brought forward by our fellow-member, Mr. Stephen Mason, in his place in the House of Commons. The English Technical Schools Bill had a clause empowering School Boards to contribute towards the maintenance or provision of any technical school, and the leader of the House of Commons was quite disposed to accept Mr. Mason's amendment, but for the opposition of one or two members from Glasgow. I shall not enter into their arguments, which were not much to the point, but it seems to me that the provisions of the Elementary Education Act relating to the appointment of managers is sufficient to get over any difficulty which is likely to arise. The School Board would control the money, and the managers would see that it was properly spent, and be responsible to the Board for the use which was made of it. I do not make this suggestion because it is the best possible, as I have already stated that I am of opinion that we require a complete reorganisation of educational matters, and this suggestion is a mere temporary arrangement, if any use is to be made of the present Bill, even in an amended form.

It seems most extraordinary that an Act should be launched on Scotland for providing technical education which entirely ignored the work of a special Commission which has been sitting for some years, and is still sitting for the consideration of the subject. Just when its labours are almost completed, and the various schemes it has arranged are being put into operation, the Members of that Commission are surprised, as I infer from the

remarks of Lord Balfour, that a Bill is passed which ignores the work they have done, and will probably have the effect of nullifying it to a large extent. Not only will the working of the Act tend to extinguish all voluntary effort of a private nature, but it is difficult to see how the operations of the City and Guilds of London Institute can be continued, in their present lines at least; for although that Institute is rich, it cannot enter into successful competition with rate-supported corporations. Sir Philip Magnus, at the recent meeting of the British Association, said he had been assured by the promoters of the Bill that they had no wish to saddle the country with the expenses of the work now being done by the Institute. On the other hand, Sir Henry Roscoe, who is understood to be one of the inspirers of the Bill, seemed to indicate that the Science and Art Department would give grants for the same subjects as the Institute. Hence we have not only the dual management of the Scotch Education Department and the Science and Art Department, but we have to consider the advisability of admitting the City and Guilds of London Institute as a third partner, or consent to the extinction of its work, at least in so far as its examinations are concerned. Into this part of the subject, however, I need not enter at present.

Lord Balfour, in the address which I have referred to more than once, expressed the opinion that, except in large centres of population, the Act would not be operative. Surely when he made that remark he forgot for the moment that in almost all the chief centres of population in Scotland, the Commission of which he is chairman had created special governing bodies to take charge of technical education, and which, with perhaps a little assistance, are qualified to undertake the greater part of what is required. If, therefore, the Act is not likely to be taken advantage of in the country districts, and is not wanted to any extent in the great centres of population, we naturally ask—What is the use of it in its present shape? It is to be hoped that Mr. Mason will accept the hint given to him by the leader of the House of Commons, and introduce a measure next session embodying his amendment, as it is very certain to pass after the expression of opinion by Mr. Smith, that we can work best through the agency of those who were content and willing to make some sacrifices of their own in order to forward the objects in view, and therefore he was by no means opposed to the principle of subsidising the efforts of persons devoted to the cause of

better and worse in social organisation, if nothing beyond the exigencies of the moment are attended to, and the proximately best is habitually identified with the ultimately best, there cannot be any true progress. However distant may be the goal, and however often intervening obstacles may necessitate deviation in our course towards it, it is obviously requisite to know whereabouts it lies." * In educational matters, not only, therefore, is it necessary to pass new regulations and inaugurate new methods, but before these can be fully taken advantage of we must get rid of old regulations which obstruct progress, and bad methods which are altogether opposed to the principles which should guide the educator. It is impossible for technical education to be much improved in State-supported schools so long as the restrictions of the present Code continue, for if we attempt to graft the new on to the old the system will break down through sheer weight. If general education were what it ought to be, a good deal of what is sometimes considered technical would be included under it. On the other hand, technical or professional education should always be general or liberal, that is to say, it should not be simply confined to the storing of facts, but be used as a means of developing the intellects of the students, and for training their eyes and their hands. To accomplish this we must have clear ideas about what we are aiming at. Public men are beginning to speak out on such matters in plain words. For instance, Lord Elgin, in the address to which I have alluded, said—"I wish to see local educational authorities in a more dignified and influential position as regards higher education than can ever be attained by even well-intentioned efforts, hampered by want of resources and by the provisions of the Code; and I wish to see our ancient universities supplied with candidates whose abilities they would not fear to put to the test. In order to realise these objects—in order to obtain that full sequence of instruction, literary, scientific, technical, mechanical, call it what you will, if it elevates and improves the individual—I am convinced that we must demand a thorough and comprehensive treatment of our secondary education, and that sooner or later we must brace ourselves to make that demand." Sir Henry Roscoe, in his recent Presidential Address to the British Association, said—"The country is now beginning to see that if she is to maintain her industrial and commercial

* Herbert Spencer, "*The Man versus The State*," p. 112.

supremacy, the education of her people, from top to bottom, must be carried out on new lines. The question as to how this may be most safely and surely accomplished is one of transcendent national importance, and the statesman who solves this educational problem will earn the gratitude of generations yet to come." In my opinion the problem is not likely to be solved by any one man, but rather by the earnest co-operation of all who are interested, not merely in education, but also in more general social questions. To aid in this solution, we require independent thought, and the courage to express the results of that thought. Unfortunately, in the present state of society that, generally, involves such serious personal social consequences that the determination required to face them is a virtue seldom to be met with. The questions involved must be bravely met and fairly considered from every point of view, for if we attempt to avoid them they will force themselves upon us in ways which will startle us. Thoughtful men are beginning to see that educational and social problems demand their best energies. To those who attempt their solution I would quote the words of a philosopher whose works I love to study—"Not as adventitious will the wise man regard the faith which is in him. The highest truth he sees he will fearlessly utter: knowing that, let what may come of it, he is playing his right part in the world: knowing that if he can affect the change he aims at—well: if not—well also: though not so well."

IV.—*On the Modern Cell Theory and the Phenomena of Fecundation.* By JOHN GRAY M'KENDRICK, M.D., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of the Institutes of Medicine in the University of Glasgow.

[Read 14th December, 1887.]

THE progress of science is not uniform. It may rather be said to advance by leaps and bounds: or, to vary the figure, one could represent the progress of science, not by a uniformly ascending line, but by a line gradually climbing upwards, having here and there in its course sudden and steep ascents, followed by portions almost horizontal. The sudden leaps are usually the result of the enunciation of a new theory which is at once an explanation of phenomena hitherto obscure, and a guide to further research, or the invention of a new instrument or method by which new fields of observation are opened up, and new facts discovered. We have an illustration of such an advance in the remarkable development of knowledge of the minute structure of living matter that has taken place during the last few years.*

It is evident that knowledge of the structure of the tissues that form the body must depend chiefly on the degree of excellence of the microscope, and on the skilful adaptation of methods of preparing the tissues for examination by that instrument. No doubt simple lenses enabled Robert Hooke,† Malpighi,‡ Grew,§ and Leeuwenhoek,|| in the 17th century, to discover some of the cellular elements, and by such simple instruments Fontana,¶ in 1784, saw and described the nucleus of the cell, adipose tissue,

* Although very full bibliographies are appended to many of the special works on this subject, I have given references as regards the more important and epoch-making memoirs, for the benefit of those who may not have the opportunity of seeing the more elaborate French and German works. In giving these references I have been specially assisted by the bibliographies of Carnoy, Van Bambeke, E. van Beneden, Flemming, Hensen, and Weismann.

† Robert Hooke, *Micrographia*, 1665.

‡ Malpighi, *Anatomia Plantarum*, 1687.

§ Grew, *Anatomy of Vegetables*, 1671 and 1682.

|| Leeuwenhoek, *Arcana naturæ detecta*, 1680. *Opera omnia*, 17

¶ Fontana, *Traité sur le venin de la vipère*, 1781.

striated muscular fibres, and the elements of nervous tissue. Little progress, however, was made until early in the present century, when, by the discovery of the principle of achromatism by Fraunhofer, and by its successful application, more recently, by Lister and others, the compound microscope became a trustworthy instrument. Since then each improvement in the microscope, as to quality of lenses, modes of illumination, and mechanical adjustments, has been accompanied by a contemporaneous advance in histology. The application of the instrument has also been facilitated by the gradual development of methods of preparing the tissues for examination. Fontana,* so long ago as before 1781, appears to have been the first to apply reagents to substances under the microscope, and he used alkalies and acids, and even syrup of violets as a colouring matter.† Little was done in this way, however, until about the middle of the present century. Since then scarcely a year has elapsed without the invention of an improved method. Thus Purkinje and Räuschel and Burdach used acetic acid as a reagent to clear up the tissues; Gerlach showed how to fill the minute blood vessels with transparent injection; H. Müller devised the method of hardening tissues by steeping them for long periods in solutions of chromic acid, or of its salts; the plan of staining certain elements was followed by Lord Sydney Godolphin Osborne,‡ Gerlach, and Lionel Beale,§ with carmine, and by Waldeyer, with logwood or hæmatoxylin; Rainey showed how to render tissues transparent by glycerine; Lockhart Clarke made it possible to render nervous tissues transparent by passing them through alcohol, oil of turpentine, oil of cloves, and finally mounting them in Canada balsam; Rollet and Schwartz invented the method of double staining, so that one element of tissue might be tinted red by carmine, whilst other elements were tinted yellow by picric acid; Ranvier, Jürgens, Dreschfield, and others called to our aid the coal tar colours; and Krause, His, and Von Recklinghausen introduced the use of salts of silver; Max Schultze, the use of osmic acid; Cohnheim, of the chloride of gold, and F. E. Schulze, of the salts of palladium, having ascertained that certain elements of tissue reduce these salts, precipitating the metal in

* Fontana, *Traité sur le venin de la vipère*, op. cit.

† Carnoy, *La Biologie cellulaire*, p. 174.

‡ Lord S. G. Osborne, *Journal of Microscopical Society*, vol. v.

§ Lionel Beale, letter quoted in Drysdale on *The Protoplasmic Theory of Life*, p. 62.

such a condition that by lines or marks the eye can follow elements in structures that otherwise would show no optical indication of their presence.* By such operations of micro-chemistry, aided by improved methods of cutting thin sections, and by the use of microscopes that, considered merely as optical instruments, are probably very near a state of perfection, much progress has recently been made, more especially in the obscure department of histology dealing with the nature of protoplasm, the structure of cells, and the phenomena of fecundation. The object of this paper is to give a brief account of some of the chief results that have been thus obtained.

As already stated, the earliest observers with the simple microscope undoubtedly saw some of the cellular elements of the tissues both of plants and of animals, but the first important step taken was by the botanist, Robert Brown,† who, in 1831, made great progress in the knowledge of vegetable cells. In particular, he directed special attention to the nucleus, previously observed by Fontana, and established the fact that it was a normal element in the cell. In 1836 Valentin‡ discovered the nucleolus, and he described it as a little round body, a kind of second nucleus, in the interior of the first. As to the physiological significance of the cell, Turpin,§ so early as 1826, was the first to attribute to them distinct individualities, and to make the generalisation that plants were formed by an agglomeration of cells. Then came the announcement of the cell theory in 1839, first applied to plants by Schleiden,|| and then to animals by Schwann. A careful study of the history of this subject has convinced me that even before 1830 the cell theory was held generally by botanists, and was discussed more especially in the writings of Dutrochet, Mayen, Schleiden, and Von Mohl; but it was not put on a sure basis until it was applied to animal tissues by Schwann. At this period, then, 1839,¶

* Arnold Brass, *Kurzes Lehrbuch der normalen Histologie des Menschen*, p. 3. Marburg, 1885.

† Robert Brown, *On the organs and mode of fecundation in Orchideæ and Asclepiadæ*. *Trans. Linnean Society*, 1833.

‡ Valentin, *Repertorium*, tom. i., 1836.

§ Turpin, *Organographie microscopique*, 1826. *Mém. of Museum of Nat. Hist.*, 1826.

|| Schleiden, *Beiträge zur Phytogenesis*. *Müller's Archiv.*, 1838.

¶ Schwann, *Microscopische Untersuchungen über die Uebereinstimmung in der Structur, und das Wachsthum der Thiere und der Pflanzen*, 1839.

the conception of a cell was as follows:—"A vesicle closed by a solid membrane, containing a liquid in which floats a nucleus containing a nucleolus, and in which also one may find small granular bodies." Further, it was held by the founders of the cell theory that all cells might originate in a structureless substance or cytoblastema. The cell theory itself was contained in the statements that the bodies of all plants and animals are formed originally of cells, and that it is by the evolution of, and changes in, these cells all the tissues are formed. (Fig. 1.)

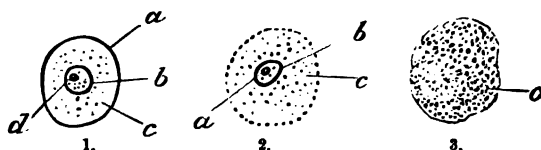


Fig. 1.—(1) Original conception of a cell. *a*, Cell wall; *b*, nucleus; *c*, cell substance or contents; *d*, nucleolus.
 (2) Cell wall has disappeared. *a*, Nucleus; *b*, nucleolus; *c*, cell substance, or contents.
 (3) Modern view. Cell now consists of granular matter, *c*. Even the faint line might be omitted; no cell wall exists.

The cell theory rapidly underwent modification under the influence of new facts and of philosophical speculation. Thus, in 1841, Henle showed that cells may multiply by budding, and in the same year Martin Barry observed that the reproduction of cells was accompanied by division of the nucleus. In 1845 Goodsir first promulgated the doctrine that cells never originate without pre-existing cells, a doctrine subsequently adopted by Remak and applied to pathological phenomena by Virchow.* Then, in 1845, the botanist, Nägeli,† showed that certain cells have no cell wall, and in 1857 Leydig defined a cell as a soft substance containing a nucleus. Lastly, in 1854, Max Schultze‡ described a non-nucleated amœboid organism, *Amœba porrecta*, which is a cell in the physiological sense, but destitute of either cell wall, nucleus, or nucleolus—nothing, in short, but a little mass of apparently structureless matter. Thus, we come back to a structureless substance, and in this connection it is interesting to read the following quotation from Schwann, because it indicates

* John Goodsir, *Anatomical Memoirs*, vol. ii., p. 90; also vol. ii., p. 389.

† Nägeli, *On the nuclei, formation, and growth of vegetable cells*. Ray Society, 1849.

‡ Max Schultze, *Ueber den Organismus der Polythalamien*, 1854; also *Protoplasma der Rhizopoden*. Leipzig, 1863.

the comprehensive view of the nature of living matter, which it was the purpose of the cell theory to explain:—"In the fundamental phenomena attending the exertion of productive power in organic nature, a structureless substance is present in the first instance, either around, or in the interior of cells already existing; and cells are formed in it in accordance with certain laws, which cells become developed in various ways into the elementary parts of an organism."*

Now we must retrace our steps to ascertain what were the earlier views held by naturalists regarding living matter. As early as 1839 Brisseau-Mirbel applied the term *cambium* to the living matter in plants, and a little later Schleiden called it *mucilage* or *schleim*. In 1835 the French naturalist Dujardin, † in describing the Rhizopoda, first used the word *sarcode* to designate "a kind of mucus endowed with spontaneous movement and contractility." Then appeared the famous word, *protoplasm*. According to Carnoy, ‡ this term was first used by Purkinje, and he makes the following quotation from Reichert, § who says, in describing Purkinje's researches, which were published in 1839 and 1840:—"There is only, according to Purkinje, a decisive analogy between the two organic kingdoms in that relating to the elementary granules of the vegetable cambium and of the *protoplasm* of the animal embryo." Six years later, in 1846, Hugo von Mohl, || in describing the tissues of plants, employed the word and defined the appearance of protoplasm in such a manner as to entitle him to the credit of the first scientific use of the term.

* For an interesting account of the earlier views regarding cells, see Dr. Drysdale's *Protoplasmic Theory of Life*, 1874. Dr. Drysdale in particular refers to the early speculations of Dr. John Fletcher in his work, published in 1835, entitled *Rudiments of Physiology*. The following quotation from that book shows how advanced Dr. Fletcher's speculative opinions were before 1835:—"Admitting that irritability or vitality, general and specific, is a property of the organised solids alone, it becomes a question of the highest interest whether it be directly inherent in each of the organised tissues, either of plants or animals, or whether it merely appears to be possessed by them all in virtue of some one which is universally distributed over the organised being, and inextricably interwoven with every other."—ii., p. 55.

† Dujardin, *Recherches sur les organismes inférieures*. *Ann. Sci. Natur.*, 2 sér., vol. iv., 1835.

‡ Carnoy, *La Biologie Cellulaire*, 1884, p. 177.

§ Reichert, *Archiv. f. Anat. und Physiol.*, 1841.

|| Von Mohl, *Ueber die Saftbewegung im Innern der Zellen*. *Bot. Zeitung*, 1846; also *Grundzüge der Anat. und Physiol. der Vegetab. Zelle*. Brunswick, 1851.

He writes:—"I am authorised to give the name of protoplasm to a semi-fluid nitrogenous substance, stained yellow by iodine, which is contained in the cavity of the cell, and which furnishes the materials for the formation of the primordial utricle, and of the nucleus." The word protoplasm, then, was first used to designate the living matter of plants, and although Dujardin* in 1835 described the properties of the living matter of animals under the name sarcode, it was a long time before naturalists recognised the practical identity of the two substances, the matter called sarcode being supposed to be peculiar to the lower orders of the invertebrates. It was not until 1861 that Max Schultze† maintained the identity of the sarcode or protoplasm of the lower beings with the living matter in the tissues of the higher beings, and it is worthy of notice that this identity was grounded not on structural but on physiological properties. Thus it was found that the living matter in vegetable cells, as shown by the well-known phenomenon of the streaming of the granules, and by the movements of the sexual elements of fungi, had properties identical with those of the sarcode of the lower animals, and with those of the living matter in the higher animals. The living stuff, wherever found, manifested *irritability* and *contractility*, and thus it was at last held that the living matter, or protoplasm, was the same in kind in both kingdoms of organized beings, from the lowest to the highest. Then it was necessary, about 1865, to define protoplasm as follows:—"A diaphanous semi-liquid, viscous mass, extensible but not elastic, homogeneous—that is to say, without structure, without visible organisation, having in it numerous granules, and endowed with irritability and contractility."

Protoplasm having been established as the living stuff, for a time it held its position as a structureless material, presenting only a few granules, and with or without a nucleus. When the bit of protoplasm was very small, even although it had no nucleus, it was considered physiologically to be a cell. But again the restive onward movement began, which led to new conquests. As early as 1844, Von Mohl,‡ in his elaborate investigations into the structure of the cell, pointed out the differentiation of the outermost

* Dujardin, *Annales des Sciences Naturelles*, vol. iii., 1835.

† Max Schultze, *Ueber Muskelkörperchen und das was man eine Zelle zu nennen habe*. *Archiv. f. Reichert und Du Bois Reymond*, 1861.

‡ Von Mohl. For an account of the researches of Von Mohl, and references, see *Sachs' Text-Book of Botany*, 1875, chap. i., *Morphology of the Cell*.

layer of the protoplasm next the cell wall to form the *primordial utricle*, the vacuolation of the protoplasm, and the nature of the nucleus, and in 1851 he limited his definition of protoplasm so as to exclude the primordial utricle and the nucleus, in the following words:—"The remaining part of the cell is more or less filled with an opaline, viscous, white fluid, having granules in it, and I call this protoplasm." Thus, as remarked by Carnoy, Von Mohl limited the name protoplasm to the hyaline viscous portion of the cell matter. These efforts of Von Mohl were the first attempts to differentiate the structure of protoplasm; they are the starting point of a vast number of researches in this direction, in which the investigator into vegetable tissues goes hand in hand with the animal morphologist.* In 1853 Professor Huxley† wrote on the subject, and distinguished between the endoplast, or the matter within the cell wall, and the periplast, or surrounding matter. He attached special importance to the endoplast, homologous with the primordial utricle of Von Mohl, and held that all differentiations of tissue were from changes in the periplast. Nor can we forget the impetus given to physiological speculation in this country by his famous lecture on protoplasm.

The first step in the direction of differentiation of the element of protoplasm was made by Stilling,‡ when, in 1859, he discovered a fibrillar structure in the interior of a ganglionic nerve cell. Five years later, in 1864, Leydig§ described a similar appearance in the cells of the intestines of certain isopod crustaceans (*Cloportes*, &c.). Between the years 1865 and 1867 Frommann|| showed that a fibrillar network existed in many cells, and in 1873 Heitzman demonstrated the same fact.¶ The two latter observers may be regarded as the founders of the modern view that almost all cells, and nearly all kinds of protoplasm,

* Special reference must be made to the writings of Professor Lionel Beale, who under the term *bioplasm* designated the living protoplasmic stuff. Modern investigations undoubtedly show that Dr. Beale's views were a very important contribution to our knowledge of the nature of living matter.

† T. H. Huxley, *B. and F. Medico-Chirurgical Review*, 1853.

‡ Stilling, *Neu Untersuchungen über die Bau d. Rückenmarks*, 1859.

§ Leydig, *Vom Bau d. Thierischen Körpers*. Tübingen, 1864.

|| Frommann, *Untersuchungen über die normale und pathologische Anatomie des Rückenmarks*, 1867, II. Theil; also *Untersuchungen über Struktur Lebenserscheinungen und Reactionen thierischer und pflanzlicher Zeller*. Jena, 1884.

¶ Heitzman, *Microscopische Morphologie des Thierkörpers im gesunden und kranken Zustande*. Vienna, 1883. His earliest paper was *Untersuchungen über das Protoplasma*. Sitz de K. A. de Wissen. Vienna, 1873.

show a delicate network of fine fibres, and they established this detail of structure as a general property of protoplasm. Thus protoplasm is not structureless, it is not a homogeneous mass having a few granules interspersed in its substance, but it has details of structure so fine as to require the highest microscopic powers, the finest optical definition, and the most refined micro-chemical operations to make them visible.* (Fig. 2.)

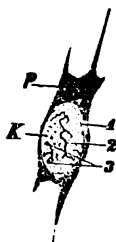


Fig. 2.—Connective tissue corpuscle or cell from the skin of *Triton taeniatum*, $\times 560$. *p*, Protoplasm; *k*, nucleus; 1, membrane of nucleus; 2, intra-nuclear network; 3, small bodies in the nucleus. The coarser threadlets of the intra-nuclear network are easily seen; the finer threadlets appear with this power as mere points. (*Stöhr.*)

The next important generalisation is as to the chemical nature of protoplasm.† Loose expressions were much in vogue eight or ten years ago, regarding this aspect of the subject. Life was said to be identified with a little albuminous matter, containing phosphorus; protoplasm was merely a drop of living albumen; and the conception one was offered of albumen was, that it was a substance like a little white of egg. But micro-chemistry, and a study of the chemical reactions of living matter have effected a revolution in scientific opinion. It is evident that living protoplasm cannot be analysed. The attempt at analysis by the application of any reagents, or by the use of physical agencies such as heat or electricity, causes it to fall to pieces, only the fragments remain, whilst the peculiar properties which we associate with the living state have vanished. We can,

* See also Klein, *Observations on the structure of cells and nuclei*, *Quart. Journal Micros. Science*, vol. xix.; also, *On the lymphatic system and the minute structure of the salivary glands and pancreas*, *Quart. Jour. of Micros. Science*, 1882; also, *Observations on glandular epithelium, and division of nuclei*, *Quart. Jour. of Micros. Science*, 1879; also, *Atlas of Histology*, 1881. chap. xliv., plate xlviii.

† Upon this point it is very interesting to read Fletcher's remarks in his *Rudiments of Physiology*, *op. cit.* An analysis is given by Drysdale, *op. cit.*

however, gather up these fragments and determine their chemical nature. They are found to consist of water, of substances having the character of the albumens, of nitrogenous matters rich in phosphorus, of carbo-hydrates, such as glycogen (animal starch) and glucose, of bodies that behave like ferments, and of mineral matters, such as chlorides, sulphates, and phosphates of the alkalies, and of the alkaline earths. Thus the protoplasmic stuff is seen to have a highly complex chemical constitution. The imagination cannot picture the complex structure of the chemical molecule. There are reasons for believing, however, that protoplasm is a chemical substance, having an extremely complex and unstable molecule, and that some of its special properties are to be referred to this complex and unstable condition. My conception of it is that it is built up by the combination of all of the substances just enumerated; whilst, on the other hand, these substances do not exist in it as albumens, or water, or carbo-hydrates, or salts. The complex molecule is like an elaborate structure, built of groups of cards; it is unstable; a slight molecular agitation causes it to fall to pieces, but, in doing so, the cards do not fall completely asunder; that is to say, it is not resolved into its elements, but they fall into groups. In other words, the molecule is resolved into the proximate substances of which it was first composed. Imagine, further, these mobile molecules ever changing, giving to, and taking from, the outer world, manifesting by their special action on polarised light, and by their reducing influence on salts of silver, the intense molecular activity that undoubtedly prevails, and one has a glimpse into the inner world of living matter.*

Let us return to the cell. During the last ten or twelve years, and especially during the last three or four years, important advances have been made, more especially as to the structure of the nucleus and the functions which it performs in the reproductive processes of the cell. It is at this stage that, if one wishes to appreciate the true position of the cell doctrine at the present time, he must study the mode of the genesis of cells,† starting

* The researches of Loew and Bokorny in *Die chemische Kräftequelle im Leben des Protoplasma*, Munich, 1882, are well worthy of study. As to the nature of living protoplasm, see also Pflüger, *Archiv.* vol. x., p. 251. The important researches of Schützenberger on the chemical nature of albumen have also a bearing on this question. See analysis of these in *Watts' Dict. of Chem.*, vol. viii., p. 1682.

† Dr. Martin Barry was one of the earliest in this country to take this view of the question. See *Goodsir's Anatomical Memoirs*, vol. ii., p. 391.

with the changes in the ovum before and after fecundation. Before, however, entering on this difficult, though profoundly interesting, subject, let us turn our attention to the remarkable observations that have recently been made on the structure of the nucleus, beginning with the appearance of a work by Professor W. Flemming, of Kiel, in 1882.* In this work Flemming gives a historical account of previous observations, and he applies a new nomenclature to the different parts of the nucleus that can be revealed by high power. He says that three substances exist in a fully-formed nucleus—first, a *reticular network* of fine fibres; second, *nucleoli*; and third, a *nuclear fluid* or intermediate substance, the whole being surrounded by a *membrane*—the membrane of the nucleus. The network he calls *Karyomiton*, (κάβιον, a kernel, μίτος, a thread), as opposed to the *Kytomyton*, (κύτος, a cell), or network in the body of the cell. The meshes of the network vary in size, they are sometimes uniform, sometimes irregular, and they often present nodosities or swellings at the points where the fibres interlace. The fibres forming the network are fixed by acids, chloride of gold, and alcohol, so as to become more apparent. The substance forming the fibres has a strong affinity for colouring matter, and on account of this property Flemming has termed it *chromatin*; but it is important to note that this word has more of a morphological than of a chemical significance, and does not involve any theory as to its chemical character. Flemming has also corroborated an observation first made by Balbiani† that the fibres of chromatin in the nuclei of the salivary cells of the larva of *Chironomus* (a *Tipula*, an insect resembling a gnat) show a transverse striation, indicating the existence of segments of different constitution. (Fig. 3.)

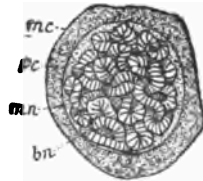


Fig. 3.—Cell from a young embryo of *Hydrophilus pisceus*. *mc.*, Cellular membrane; *pc.*, protoplasm; *mn.*, membrane of nucleus; *bn.*, nuclear thread or filament striated, immersed in a finely granular plasma. (*Carnoy.*)

* Flemming, *Zells substance, Kern, und Zelltheilung*. Leipzig, 1882.

† Balbiani, *Sur la structure du noyau des cellules salivaires chez les larves de Chironomus*, *Zool. Anzeiger*, 1881.

In the meshes of the reticulum lie one or more nucleoli, small portions of nuclear substance of distinct constitution from that of the reticulum or of the nuclear fluid. They are not to be regarded, however, as variable fragments of nuclear matter, but as specific products, the result of those molecular actions of which the nucleus is the seat. Flemming holds that these minute structures have probably a determinate physiological purpose. Further, he states that there are differences between the nucleoli of the same nucleus, classifying the larger and more regular in appearance as principal nucleoli, and the others as accessory nucleoli. There are also differences between the nucleoli of different cells, more especially as regards the existence in them of minute vacuoles, or round spaces. He has also noticed extremely slow changes of form in the nucleoli of certain living cells. In the changes attending the division of the nucleus in cell division the nucleoli disappear, and after cell division they reappear. Flemming is of opinion that their disappearance arises from a distribution of their substance through the nucleus, and that their reappearance or genesis is a function of the reticular network. He has also observed that in general, but not always, the absolute volume of the nucleoli is proportional to the volume of the nucleus. Finally, in the nuclei of the cells in the salivary glands of *Chironomus*, the chromatin appears as a filament instead of a reticulum, and Flemming states that the ends of the filament are attached to the nucleoli. (See also Fig. 3.)

Flemming has observed in the great majority of nuclei a limiting membrane, or envelope, and he distinguishes in some cases an achromatic and a chromatic membrane. The first—the achromatic—so termed because it does not stain readily, is found in the germinal vesicle or nucleus of many ova. The chromatic membrane is sometimes perforated by small holes, and according to Frommann, Klein, and others, anastomoses of the intra-nuclear and intracellular networks may thus exist.*

Lastly, the nuclear fluid is probably a solution of saline matters, along with albuminous and other organic constituents.

As I have detailed these characters according to the descriptions of Flemming, it will have been evident that the nucleus is not the

* It is unfortunate that the terms *chromatic* and *achromatic* have been introduced in the terminology of nuclear structures, as these words have a definite meaning in physical science, employed in describing other phenomena.

simple structure that has been hitherto supposed. These observations have been repeated by many of the most careful workers, by such men as Strasburger, Levitz, Pitzner, E. van Beneden, Carnoy, Frommann, Klein, Brasse, furnished with the best microscopic appliances, and thoroughly familiar with the interpretation of microscopic appearances. It is not surprising, however, that whilst all admit that a new world of real phenomena has been opened up, there are considerable differences of opinion and a good deal of confusion from the unfortunate tendency to the introduction by each new observer of his own nomenclature. Recently Professor van Bambeke, of Gand, in Belgium, has attempted to introduce order into this mass by a systematic study and classification of the observations and views of different authors.*

Thus, with reference to the nature of the fibrous appearance seen in nuclei, observers may be arranged in two classes: 1st, Those who follow Flemming in regarding it as a reticulum or network, namely, Pitzner, Retzius, Levitz, Van Beneden, &c.; and 2nd, those who hold the reticulated appearance to be due to the presence in the nucleus of a coiled-up filament, namely, Strasburger, Badiani, Carnoy, &c. Most of those in the first category agree in the general description of a reticulum, but they differ as to terminology, and as to certain minute details of structure which the observer believes he has demonstrated. Thus, E. van Beneden,† in his researches on the fecundation of an intestinal worm found in the horse, *Ascaris megalocephala*, describes the nucleus as consisting of a membrane, within which there is a network of chromatin, containing in its meshes a fluid substance. The whole of this mass forming the membrane and reticulum he calls *nucleoplasm*, and he describes it as consisting of two portions: 1st. An *achromatic substance* arranged in fine moniliform filaments; and 2nd. a *chromatic substance* which is imbibed by the membrane and by the reticulum, and which also fills the meshes. Further, he supposes that each fibre or filament consists of numerous minute bodies, *nucleomicrosomata* (readily stained), between which the chromatic substance exists, and the more elongated fibrils he terms *nuclear-threads*.

* Charles van Bambeke, *État actuel de nos connaissances sur la structure du Noyau Cellulaire à l'état de Repos*. Gand, 1885. At the end of this little work there is an excellent Bibliography.

† E. van Beneden. *Recherches sur la Maturation de l'œuf la Fécondation et la Division cellulaire*. Gand, 1883.

On the other hand, Strasburger* describes a nucleus as consisting of *nucleoplasm* (or *Karyoplasma*), in which, as in *Kytoplasma*, there are two matters: the *nucleomicrosomata*, taking up pigment, and the *nucleohyaloplasma*, which is not stained. The nucleoplasm is an elongated filament, of variable thickness, crossing in loops in all directions, and thus giving rise to the reticulated appearance.

Balbiani describes the chromatin in the germinal vesicle of the rabbit as existing in the form of a cord, and in *Chironomus* the cord is striated as if it were composed of discs. This cord is thrown into folds, or it may be broken into fragments, and the fragments lying loosely together give rise to the appearance of a reticulum.

Arnold Brass,† of Marburg, takes a somewhat different view of the constitution of the chromatin filament. He says it is the seat of metamorphoses by which it may vary much in consistence, so that sometimes it may be squeezed out of nuclei into long filaments. Further, he holds that the chromatin filament is not one substance, but a mixture of various substances, as he does not find the reagents he employs act upon it uniformly. If it be in a state of solution, then there may be no appearance of structure in the nucleus, and it may be called a *homogeneous nucleus* (a condition rarely met with); or it may appear in the form of granules or filaments which may either anastomose or form one long coiled-up filament.

In a recent research into the nucleus in many cells of *Proteus* and of *Triton cristatus*, Rabl‡ has observed that the reticulum of the epithelial cells of the bladder is slight and delicate, whilst those of the muscular cells in the same organ are more massive, and he remarks that this may have a genetic significance. Further, this author has attempted to classify nuclei according to the nature of the reticulum. Thus we may have a reticulum with nodular swellings at the junctions of the fibres, but without nucleoli; a reticulum with nucleoli; or there may be a coiled filament.

* Strasburger, *Archiv. f. mikr. Anat.*, 1882, 1884; also *Neue Untersuchungen über den Befruchtungsvorgang bei den Phanerogamen als Grundlage für eine Theorie der Zeugung*. Jena, 1884.

† Arnold Brass, *Die Organisation der thierischen Zelle*, 1884; also *Lehrbuch der Histologie des Menschen*, op. cit., p. 21, et seq.

‡ Carl Rabl, *Ueber Zelltheilung*, *Morphol. Jahrbuch*, 1884.

Carnoy* describes a nucleus as a kind of little cell containing a cord or coiled filament of nuclein. Each nucleus has, then, (1) a protoplasmic body, and (2) a portion formed of nuclein, which is the chromatin of Flemming. He also terms the protoplasmic portion *Karyoplasma*, a hyaline mass, homogeneous in appearance, and having granules interspersed. Carnoy sums up his conclusions as to the first constituent, the nuclein (or chromatin), in the following propositions:—

1. In typical nuclei the element nuclein presents a filamentous form; it is composed of a continuous or coiled filament.
2. The chromatic reticulum of Flemming is only an appearance due to the regular crossing of its convolutions, rarely to their temporary union. (Fig. 4.)

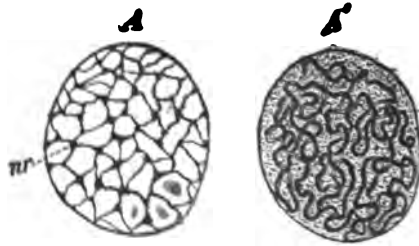


Fig. 4.—Two nuclei of the epidermis of *Salamandra maculata*. *A*, Nucleus at rest. The nuclear filament forms a network by the convolutions being fused so as to present thickenings, *nr*. *A¹*, nucleus before division, or Karyokinetic process. The filament seen in *A* is now swollen, and its convolutions are separated so that one long coiled filament is seen.

—(Carnoy.)

3. The nuclear filament is subject to profound changes. Thus it may be broken into fragments, or even into spherules, whilst it may dissolve and totally disappear.

* Carnoy, *La Biologie cellulaire*. Reference is also made to the magnificent monographs in *La Cellule*, Gand, published during the last few years. No more striking testimony could be given to the importance attached to the elucidation of the structure of the cell than the appearance of the parts of this work from time to time. M^{re} le Chanoine J. B. Carnoy is Professor of BIOLOGIE CELLULAIRE in the Catholic University of Louvain, and the contributions have been made by himself, along with some of his colleagues and pupils. In particular, I have gained much information from the following papers:—*La cytodivision chez les arthropodes*, by Carnoy, tom. i., fasc. i. and ii.; *Étude comparative de la spermatogenèse chez les arthropodes*, by G. Gilson, tom. i., fasc. i. and ii.; also, *La cytodivision de l'œuf*, by Carnoy, tom. ii., fasc. i., and tom. iii.

4. The nuclear filament is structural. One may distinguish a wall, a tube, and contents. Even the contents may be organised, appearing in the form of discs, &c.

5. Usually the nuclear filament does not occupy a determinate position, but it may be localised towards the centre of the nucleus, forming a nucleolus.

But the Karyoplasma, or protoplasmic portion, of Carnoy, like the Kytoplasma (cellular plasma), is formed of a *reticulum* and an *enchylema* ($\chiυλδς$, juice or moisture of plants, afterwards applied to animal fluids, such as chyle), a substance in the meshes, or the intermediary substance, or nuclear fluid of other authors. (Fig. 5.)

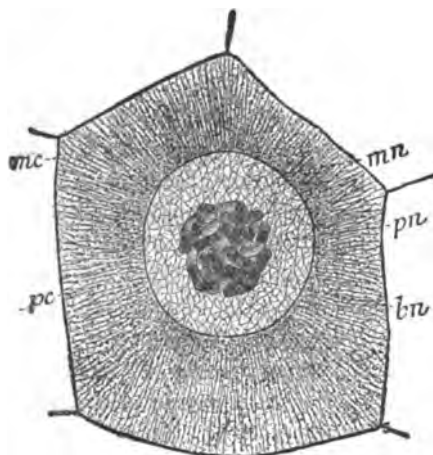


Fig. 5.—Cell and typical nucleus of the intestinal epithelium of a maggot—*mc*, cellular membrane; *pc*, cellular protoplasm: observe the radiating reticulum with the enchylema or juice enclosed in the meshes; *mn*, membrane of the nucleus; *pn*, plasma of the nucleus: here observe, also, a reticulum and plasma, distinct from those of the protoplasm; *bn*, continuous nuclear thread or filament, contracted in the centre of the nucleus and showing numerous loops. (Carnoy.)

One other research it is important to notice, as it relates to the chemical nature of nuclear matter. In 1871 Miescher* found in the nuclei of cells a substance to which he gave the name *nuclein*. It has been isolated from pus cells in sufficient quantity for purposes of analysis, and appears as a greyish mass, insoluble in dilute hydrochloric acid, but soluble in a weak solution of caustic soda. The analyses given by Miescher of the nuclein from salmon

* Miescher, *Verhandl. d. naturf. Ges. in Basel*, 1874.

nuclei, and by Hodge-Seyder of the nucleus of pus cells, agree in showing from 1.55 to 2.75 per cent. of phosphorus. Further, in the nucleus of yolk of egg, Wurm-Müller found 2.2, 2.61, and 7.4 per cent. of phosphorus. In 1882 and 1883 Zacharias* repeated Miescher's observations on nuclei, only using the methods of micro-analysis of macro-chemistry, and he arrived at the important conclusion that two chemical matters exist—1. *nuclein*, which gives the same reactions as the soluble nucleus of Miescher; and 2. *plastin*, a matter which gives different reactions. Further, he states that nuclei contain a *fibulamentous substance*, nearly related to protoplasm, which is chiefly, if not wholly, plastin, whilst nuclein is the same substance as nuclein. He supposes also that the matters termed chromatin by Flemming are probably mixtures of plastin and nuclein.

If we attempt to make a critical estimate of the result of these numerous investigations, we may reach the following conception of a nucleus.—1. It is a small round or oval body, having an envelope or membrane, and containing a reticulum or network, in the meshes of which there is a semi-fluid matter; (2) in some cases, possibly in all, at a definite period in the life of the nucleus, instead of a reticulum there may be a coiled filament or a series of filaments, not anastomosing, floating in a nuclear fluid; (3) to the matter forming the reticulum, or forming the filament or filaments, the name chromatin may be given, inasmuch as this readily takes up colouring matters; but as staining fluids do not tint the whole of the chromatin filament uniformly, it is highly probable that another substance exists in the chromatin filament, and in the membrane of the nucleus, which may be provisionally termed achromatin, and which possibly forms the organic basis of the whole structure; (4) to the semi-fluid matter the name of nuclear fluid may be given; (5) in the meshes of the reticulum, or in the coils of the filament, there may be one or more small bodies (nucleoli) which appear to be of the same nature as the chromatin filament, but which, from their uniform presence in the nuclei of certain cells, and from their behaviour in the process of cell division, are probably portions of nuclear matter having a special physiological significance, at present only conjectural; and (6) there is no absolute proof that there is any connection between

* E. Zacharias, *Ueber den Zellkern*, Bot. Zeit., 1882, and *Ueber Einsen, Nuclein und Plastin*, Bot. Zeit., 1883.

the chromatin filaments in the nucleus and the network of fibres in the cell substance outside the nuclear wall.

Such being the structure of the nucleus, the next and most important question is—What part does it perform in the process of cell division? It was in 1841 that Martin Barry* first observed that the division of cells was associated with division of the nucleus, and for many years it was supposed that this was simply a fission of the nucleus, followed by a fission of the whole cell, so that the daughter nucleus was contained in the new cell. It was also observed that in many tissues nuclei might apparently divide without fission or division of the matter in which they existed, so that certain cells or tissues contained several nuclei. The simple division of the nucleus, without any changes occurring in that structure, and followed by division of the protoplasm of the cell, is called *akinetic*, or *direct division* (κινέω, to move, to set a-going). A better term, I think, is that suggested by Carnoy,† *Karyostenosis* (κάρυον, a kernel; στενώνω, a being straitened; στενώνω, to make narrow). This mode of division has been observed by Ranvier in the leucocytes of *Siredon pisciformis*; by Lavdowski in the leucocytes of other Batrachians; by Nussbaum in the regeneration of epithelium of the cornea of the frog; by E. van Beneden and C. Julin in the multiplication of the spermatomeres of *Ascaris megalocephala*; by Sabatier in the spermatogenesis of decapods; and by Carnoy in the fat cells, muscle cells, and in other cells of Arthropods.‡ It appears also to be the mode of division of the parenchyonatus cells of plants, of certain Algæ, and of the Infusoria. (Fig. 6.)

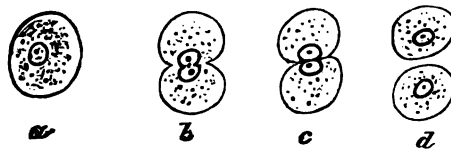


Fig. 6.—Direct cell division, or Karyostenosis—*a*, fully formed cell; *b*, beginning of division of nucleus and also of cell substance; *c*, division of nucleus and of cell substance complete; *d*, formation of two new cells.

* Martin Barry, *Phil. Trans.*, 1839, 1840, 1841.

† Carnoy, *La Cellule*, tom. i., fasc. ii., p. 409.

‡ Quoted by Carnoy, *La Cellule*, op. cit., p. 409.

The other mode of division, sometimes called indirect division, or *Karyokinesis*, a term first used by Schleicher, was first described by Professor Bütschli,* of Heidelberg, in 1876, as occurring in the cells of the testis of *Blatta germanica*, in two blastodermic cells of *Musca vomitoria*, and finally in the parthenogenetic egg of *Aphis*. Since then this mode of division has been found by many others in organisms, both plant and animal. It appears to be common in the Vertebrates, and may be readily demonstrated in the epidermal cells of Amphibians. The process may be described as follows, with the use of the terms suggested by Flemming†:—The chromatin of the nucleus is increased, and is developed into a complexly coiled thread, called the *spirem* (σπείρημα, a wreath, a coil, or spire), while the nucleoli and the membrane of the nucleus disappear. The thread is next divided into portions which assume the form of *loops*. These are at first placed irregularly, but they are soon arranged in such a way that the tops of the loops are turned towards the clear middle part of the nucleus, while the free ends of the loops are directed towards the circumference. This form is termed the *aster* (ἀστήρ, a star), or *garland*. The loops are next divided in the direction of their length, whereby their number is doubled, but the loops themselves become thinner. Then the loops are collected towards the middle or equator of the nucleus, so as to form a flat body around it, called the *equatorial plate*. Shortly afterwards the loops separate into two groups, each group retreating towards the pole of the nucleus, giving rise to the *barrel-form* or *pithode* (πίθωδης, like a cask). The groups of loops now separate still further, and having the closed ends of the loops towards the poles, give rise to a double star, or *dyaster*. Then there begins at the equator of the cell a division of the protoplasm, which leads to its complete separation into two equal parts. The groups of loops again become irregularly coiled up, like a clew, giving rise to an appearance called *dispirem*, and, finally, these remarkable movements subside, and the threads of chromatin again assume the form and arrangement seen in a nucleus in repose. The duration of this process has been ascertained to be as short as half an hour in men, while in Amphibians, where it is most easily studied, it may occupy five hours. According to Carnoy, several

* Bütschli, *Studien über die ersten Entwicklungserscheinungen der Eizelle, die Zelltheilung und die Conjugation der Infusorien*. Frankfurt, 1876.

† Flemming, *Zellsubstanz, &c., op. cit.*

of these changes may be omitted, and he states that there are many gradations between the karyostenotic and the karyokinetic modes of nuclear division. (Fig. 7.)

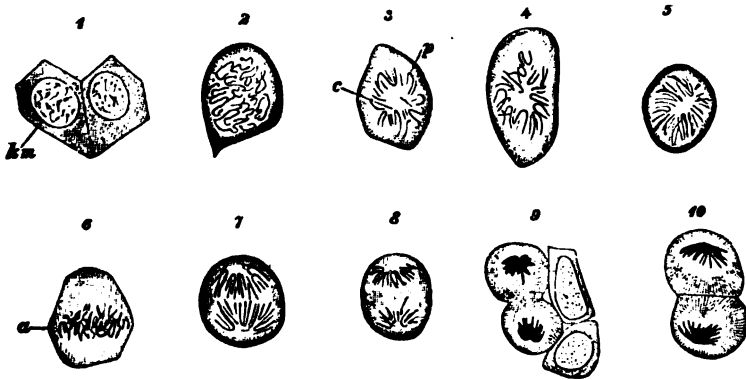


Fig. 7.—Views of the various stages of Karyokinesis, or division of the nucleus, from a section of the epidermis of *Triton teniatus*, $\times 560$. 1. Two epithelial cells, in which are seen the nucleus, the membrane of the nucleus *km*, and the dark-coloured network. 2. Disappearance of the nuclear membrane—*Spirem*. 3. Nuclear threads in groups and having the loops dividing at the centre *c*, or at the periphery *p*. 4. *Monaster*, in which the loops are directed to the centre. 5. The loops are thin and very numerous, in consequence of division. 6. *Equatorial Plate*. 7. *Barrel-form*. 8. *Dyaster*. 9. Contraction of the protoplasm of the cell; both the neighbouring cells show nuclei, the network in which is not distinguishable. 10. Complete division of the cell, the nuclei in which have not yet returned to the original resting condition seen in 1. (*Stöhr.*)

Having thus endeavoured to give a concise account of the modern views held as to the nature of protoplasm, cells, and nuclei, I shall content myself in this paper with placing before you a short description of the chief changes that have been observed in the process of fecundation by which the primitive cells of the body are formed, because, as I previously remarked, the phenomena of fecundation and those of cell division ought to be studied together if one desires a comprehensive view of the subject. It is of course well known that fecundation consists in the blending of the male and female elements. Strictly speaking, it may be now defined as the blending of two nuclei, one derived from the female, and the other from the male parent cell.

The male element is represented by the *spermatozoid*, first discovered by Louis Ham,* a pupil of Leeuwenhoek, in 1677, and the spermatozooids of mammals, birds, fishes, molluscs, and of certain insects were described by the latter. They were then, and for many years after, termed animalcules, but Buffon,† with more insight, applied the name living molecules. It was many years before the idea of their individuality as specific organisms was abandoned, and it was not until the observations of Prevost and Dumas‡ in 1824, of Kolliker§ in 1841, and of Newport|| in the year 1850 that their true position as constituent elements of the body was recognised. Their development was first traced to some extent by Von Siebold¶ and Leuckart** in 1836; in 1846 Kolliker first asserted that they were essentially nuclei developed in certain cells of the testes. At first Kolliker held that they were developed in the interior of nuclei, but as Henlett in 1854 showed that not only the nucleus but part of the protoplasm of the cell forming the tail took part in their evolution, Kolliker, in 1856,†† modified his first opinion to the extent of stating that the whole nucleus entered into the formation of the spermatozoid. In 1863 Schweggen-Schmidt§§ went a step further, and asserted that the spermatozooids were not merely nuclei, but were in the ovulatory follicle cells each carrying a vitelline cilium.

It has been found extremely difficult to trace the origin of the spermatozooids in the cells in the testes of the testis, and the ovulatory follicle cells now be regarded as settled. Kolliker,¶¶ in 1846 described two kinds of cells, at first larger, with large

* On a small insect, *Hydrophilus*, and a human spermatozoid in *Hydrophilus* were first described in the *Philosophical Transactions*, 1777, p. 22. See also article, *Hydrophilus*, in *Encyclopædia Britannica*, 18th edition, 1830, p. 22.

† *Philosophical Transactions*, 1777, p. 22.

‡ *Philosophical Transactions*, 1824, p. 22.

§ *Philosophical Transactions*, 1841, p. 22. See also *Annals of Philosophy*, 1841, p. 22.

|| *Philosophical Transactions*, 1850, p. 22.

¶ *Philosophical Transactions*, 1836, p. 22.

** *Philosophical Transactions*, 1836, p. 22.

†† *Philosophical Transactions*, 1856, p. 22.

§§ *Philosophical Transactions*, 1863, p. 22.

¶¶ *Philosophical Transactions*, 1846, p. 22.

|| *Philosophical Transactions*, 1850, p. 22. See also *Annals of Philosophy*, 1850, p. 22.

¶¶ *Philosophical Transactions*, 1846, p. 22.

nuclei and nucleoli, and an inner layer of smaller cells, which were the true sperm cells. The sperm cells became cysts in which the spermatozooids were developed. In 1871 Merkel* described a ramified set of cells in the tubules which formed a kind of support or framework on which the spermatozooids were formed, and in the same year Von Ebner† developed this idea and figured peculiar branching structures on which the spermatozooids originated. These outgrowths from the living membrane of the seminiferous tubules he called *spermatoblasts*. Each spermatoblast has a number of rounded lobules, and each lobule gives rise to a spermatozoon, the nucleus lengthening to form part of the head, while a thin film of protoplasm forms the tail. As the young spermatozooids develop they are at first closely connected with the spermatoblast, but when set free they roll off into the tubule. In 1875 Sertoli‡ described the development of spermatozooids in the Elasmobranchs (Sharks, Rays, &c.) He traced the invagination of the primitive germinal epithelium into the underlying stroma, so as to form a follicle, and in certain of the cells of this follicle—"mother cells,"—the nucleus divided so as to form a number of minute bodies, each of which became a spermatozoid. Von la Valette§ examined spermatogenesis in the vertebrates and published his results in 1878. According to him, two sets of cells exist in the tubules; one set, like young ova, he calls *spermatogonia*; these divide into numerous smaller cells, *spermatocytes*, each of which may form a spermatozoid, as in mammals, or they may take part in the formation of supporting structures or envelopes for the spermatozooids, as in fishes and amphibia; the other set of cells do not take any part in spermatogenesis. Lastly, Renson,|| in 1882, describes the larger cells of Von la Valette as forming cysts called *spermatogemmæ*, each containing a number of *nematoblasts*, which become the young spermatozooids. These nematoblasts, when liberated from the cyst, cluster round certain elongated

* Merkel, *Archiv. f. Anat. und Physiol.*, 1871.

† Von Ebner, *Archiv. f. Anat.*, 1872.

‡ Sertoli, *Gazette medicale lomb.*, 1875.

§ Von la Valette, *Archiv. f. Micros. Anat.*, xii. and xv., also article in Stricker's *Handbook of Human and Comparative Histology*, vol. ii., p. 131.

|| See Patrick Geddes' article *Reproduction*, *Encycl. Britan.* Renson, *Archiv. d. Biologie*, 1882. For an excellent account of the literature of mammalian spermatogenesis, see Herbert H. Brown's paper on *Spermatogenesis in the Rat*, *Quart. Jour. of Micros. Science*, 1885.

epithelial or supporting cells, similar to the spermatoblasts of Von Ebner, and become buried in the protoplasm until their full development. They may even penetrate to the bottom of the spermatoblast (supporting cell), but this structure then grows outwards and carries the spermatozooids to the centre of the seminiferous tubule, where they are finally discharged.

Many other views have been offered, but those which I have detailed may be regarded as typical expressions of opinion on this difficult question. It is evident that the spermatozoon is a highly differentiated structure, requiring specific arrangements for its maturation and development. (Fig. 8.)

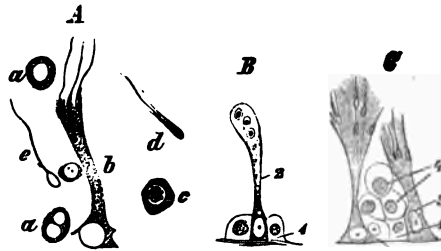


Fig. 8.—A, Isolated elements of the testis of an ox. *a*, Seminal germ cells; *b*, spermatoblast; *c*, indifferent seminal cell; *d*, torn off (?) process of a spermatoblast; *e*, almost finished thread, with a remainder of protoplasm near the middle. *B* and *C*, from a section of testicle of ox. 1, Seminal germ cell; 2, spermatogemme; 3, spermatoblast; 4, indifferent seminal cells, $\times 240$. (Stöhr.)

Spermatozooids vary much in form. The familiar type is that showing an oval head and a long filament or tail. It is remarkable that this comparatively simple form is found both in the higher and lower groups. Thus it is met with in the sponge, in medusæ, in tape-worms, and in mammals generally, including man. On the other hand, the spermatozoa of various intestinal worms (*ascaris*), and of arachnids, are irregular in shape, like amœboid corpuscles; in the newts and salamanders the tail may be fringed by a membrane, and in many birds the tails are of enormous length.

The *head* of the spermatozoon is of special physiological importance because it is the part containing the chromatin (or nuclein), derived from the nucleus, consequently it is readily stained with colouring matters. The *tail* is formed of protoplasm. Some have described certain small nuclei in the spermatoblasts that do not enter into the formation of the spermatozooids, and in accordance

with the theory to be afterwards mentioned, that all cells may be regarded as hermaphrodite, that is to say, as containing both male and female elements; these have been termed *female nuclei*. This is a very doubtful interpretation.

In man the head of the spermatozoon is from 3 to 5* μ long, and 2 to 5 μ broad; the middle portion, that is to say, immediately behind the head, is about 6 μ in length, and 1 μ broad, and the tail is from 40 to 50 μ long, and runs out to a fine point.† (Fig. 9.)

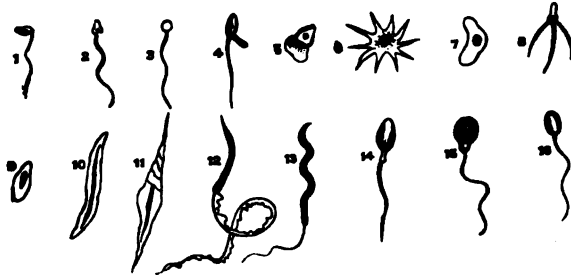


Fig. 9.—Forms of spermatozoa. 1, Sponge; 2, Medusa; 3, *Bothriocephalus* (Tape-worm); 4, *Cleta* (chætopod); 5, *Ascaris* (Thread-worm); 6, *Moina* (Daphnid); 7, Crab; 8, Lobster; 9, 10, 11, *Plagiostomum* forms with elongated nucleus; 12, Salamander; 13, Ray; 14, Man; 15, *Cobitis* (Snake ?); 16, Mole (*P. Geddes*).

Spermatozoa have remarkable powers of resistance. The sinuous movements belong to the tail, which pushes the head before it. While in the testicle these movements scarcely exist, and it is only when the spermatozooids reach the fluid secreted by the epididymis, by the *vesiculæ seminales*, by the prostate gland, and by Cowper's glands, that the movements become active, probably owing to a stimulating action of these fluids. The movements may go on for from 24 to 48 hours after removal from the body, if in favourable circumstances. Water arrests the movements, but they may recommence on the addition of very weak alkaline fluids. Even extremely weak acids at once kill the spermatozooids.

We must now turn our attention to the nature of the *ovum* or egg.‡ This is found in a special organ termed the ovary, an organ

* μ = 1 micro-millimetre, that is to say, the 1-1000th of a millimetre, 1 mm. = 1-25th inch; 1 μ = 1-25000th of an inch.

† Philipp Stöhr, *Lehrbuch der Histologie*. Jena, 1887, p. 170.

‡ For a historical sketch see Allen Thomson's article, *Ovum*, in *Todd's Cyclopædia of Anatomy and Physiology*; also Patrick Geddes' article *Reproduction*, *Encycl. Britan.*

for many years, from the time of Galen to the middle of the 17th century, described as *testes muliebres*. De Graaf,* in 1672, was the first to describe the ovary carefully. He described the vesicles that bear his name, the *Graafian vesicles*, which, however, he regarded as ova, and he stated that ova were structures to be found throughout the whole range of the animal kingdom. He also observed the ovum itself in the rabbit. Little progress, however, was made till 1825, when Purkinje† discovered the *germinal vesicle* in the ovum of the common fowl. Then, in 1827, Von Baer‡ traced the changes in the ovum from the uterus back to the Graafian vesicle. Soon afterwards Coste§ showed that Purkinje's vesicle occurred in the mammalian ovum, and in 1836 Wagner|| discovered the *germinal spot*, sometimes, therefore called Wagner's spot. From this date until the last few

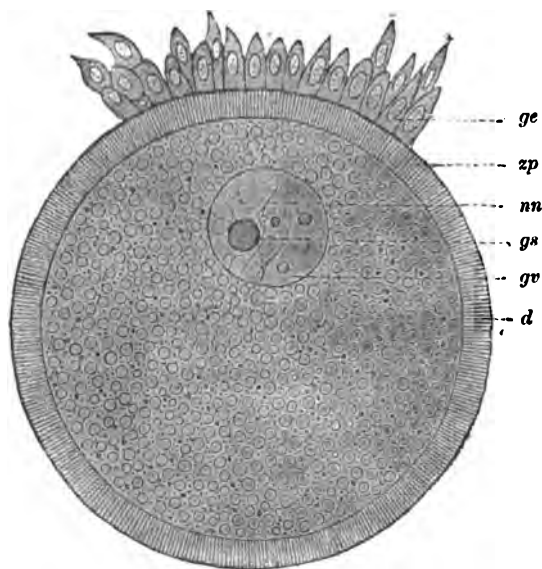


Fig. 10.—Ovum of Rabbit from an egg follicle, 2 mm. in diameter. *zp*, Zona pellucida, having at the top, cells of the germinal epithelium, *ge*. The yolk shows corpuscles of deutoplasm, *d*. In the germinal vesicle, *gv*, is the nuclear network, *nn*, with a large nucleolus, the germinal spot, *ga*. (*Waldeyer*.)

* Regner de Graaf, *De mulierum organis generationi inservientibus*, 1672.

† Purkinje, *Symbolæ ad ovi avium hist.*, 1825.

‡ Von Baer, *Burdach's Physiologie*, vol. ii., 1828.

§ Coste, *Recherches sur la génération des mammifères*. Paris, 1834.

|| Wagner, *Prodomus Hist. Generationis*. Leipzig, 1834.

years little progress was made in the study of the minute structure of the ovum, and it was described as a typical cell, having a cell wall, the *zona pellucida*, or *vitelline membrane*, surrounding the contents, or *yolk*, in which lay embedded the *germinal vesicle*, or nucleus, which had a nucleolus—the *germinal spot*. The ovum has shared, however, in the recent progress made in the study of the structure of the cell, and the structure of nuclei, and now we know that the nucleus shows the threads of of chromatin, or a reticulum with wide and irregularly formed meshes.* (Fig. 10.)

The *ovaries* consist of connective tissue and of a glandular substance. The connective tissue, forming the *stroma* of the ovary, is arranged in various strata, and contains numerous vessels. In the outer part of the stroma is the so-called glandular substance, which contains numerous small follicles, about 36,000 in the human being, each having in it a small ovum or egg.† It is remarkable that at an early period of intra-uterine life, vast numbers of ova are found in the ovary, even during its development. Many of these never come to maturity. Most of these follicles are extremely small, measuring not more than 40 μ . The larger follicles in which the ova reach maturity



Fig. 11.—From a section through the cortex of the ovary of a rabbit, $\times 90$. 1, Primary follicle; 2, follicle lined with a layer of cylindrical epithelial cells; 3, follicle with stratified epithelium. K, Germ epithelium. T, Tunica albuginea (slightly developed). Th, Theca folliculi. Fe, Follicle epithelium. Zp, Zona pellucida. D, Yolk. Kf, Germinal vesicle with punctiform germ spots. (Stöhr.)

* Ransome, *Observations on the egg of osseous fishes*. *Phil. Trans. Roy. Soc.*, 1867.

† Philipp Stöhr, *op. cit.*, p. 174.

lie much deeper. The upper surface of the ovary is covered with *germ epithelium*, consisting of small, short, cylindrical cells. In the embryonic period the ova pass through only the first stage of development, and their further development takes place in the Graafian vesicles. In the fœtal period, and even after birth, we find between the cylindrical cells of the germ epithelium large roundish cells, provided with a nucleus and nucleolus. These are the *primordial ova*, which have originated from single cells of the germ epithelium. (Fig. 11.) It is important to note, in passing, that this germ epithelium is the same that gives rise in the male to the cells that have to do with the production of spermatozooids. (Fig. 12.) In the course of

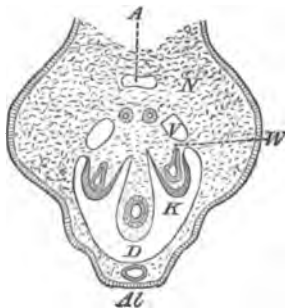


Fig. 12.—Diagrammatic section through the posterior end of a young warm-blooded embryo, the spinal cord not shown. *A*, Aorta; *N*, Renal canal; *V*, Veins; *Al*, Canal of allantois; *D*, Intestinal canal. Round this is the peritoneal cavity, and at *K* the germinal epithelium. *W*, Canal of the primitive kidney. (*Waldeyer*.)

development groups of cylindrical cells grow up from the stroma of ovary, so as to enclose the primordial ova. These may even form tubular-like structures, called by some German writers the *ova tubes*. By-and-by each ovum is surrounded by cells, forming a little round body called the primary follicle, which consists of the ovum and of epithelial cells surrounding it. The formation of this follicle around each ovum is for the purpose, in due time, of ejecting the ovum from the ovary. The size of the follicle increases by the multiplication of epithelium cells, and by-and-by a space exists round the ovum, which is filled with a fluid, the *liquor folliculi*. This liquid may be formed by transudation from the surrounding blood vessels, and, as some have suggested, by the disintegration and melting away of some of the epithelial cells. We have now a vesicle filled with fluid, the Graafian vesicle, having a diameter of from .5 to 5 mm. The connective tissue forms the

wall of the vesicle. It now consists of (1) a connective tissue covering, the *theca folliculi*, which is formed of two strata, an outer (*a*) of fibrous tissue, *tunica fibrosa*, and (*i*) an inner, *tunica propria*, rich in cells and vessels: (2) a lining of stratified follicular epithelium, sometimes called *membrana granulosa*. This lining of epithelial cells forms a prominence at one side, called the *cumulus ovigerus*, or *discus proligerus*, and the layer surrounding the ovum has been termed the *tunica granulosa*. The space is occupied, as already mentioned, by the *liquor folliculi*. A fully mature human ovum measures in diameter from 1-125th to 1-150th of an inch. The germinal vesicle is about the 1-500th of an inch in diameter. It is important to note in this connection that the head of the spermatozoid is the 1-6250th of an inch in length and about 1-8000th of an inch broad, so that the size of the male nuclear element is only about 1-12th part that of the female nuclear element. (Fig 13.)

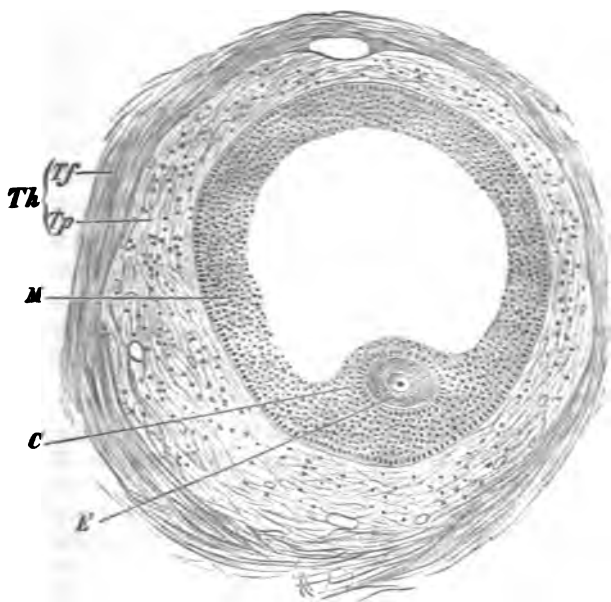


Fig 13.—Section of the Graafian follicle of a girl 8 years old, $\times 90$. *Th*, Theca folliculi. *Ty*, Tunica fibrosa. *Tp*, Tunica propria. *M*, Membrana granulosa—follicular epithelium. *C*, Discus or cumulus ovigerus. *E*, Ovum, with zona pellucida, germinal vesicle, and germinal spot. The clear space in the middle contains the liquor folliculi. (Stöhr.)

When the ovum reaches maturity, the Graafian vesicle is full of fluid, and, as already mentioned, bulges out from the surface of the ovary. The vessels in the neighbourhood of the vesicle become much congested, and at a given time the vesicle bursts, and extrudes its contents. This is assisted by a rupture of some of the finer vessels, causing a hæmorrhage into the cavity of the vesicle. Coincident with these changes, by a reflex mechanism, the exciting cause of which is not known, the end of the Fallopian tube is applied to the ovary, and the ovum escapes into it, to be carried to the uterus. During its passage down the Fallopian tube, it meets with the spermatozooids, and then fecundation occurs.

The question now arises—What is the influence of the spermatozoid upon the ovum? * It is interesting again for a moment to notice the historical development of knowledge upon this question. The first step in this direction was made by Kölreuter† in 1761, when he succeeded in artificially producing hybrids by the cross fertilization of plants. Soon after this Jacobi‡ artificially fertilized the eggs of the trout and salmon, and in 1780 Spallanzani§ operated in the same way on the frog, the tortoise, and the dog. Curiously, however, he thought that the virtue lay in the fluid and not in the living particles. In 1824 Prevost and Dumas|| proved that the seminal fluid lost its effect after filtration. Martin Barry¶ observed spermatozooids in the ovum of the rabbit in 1843; Leuckart** made the same observation in the frog in 1849; Nelson†† in 1852 observed the spermatozooids in the egg of *Ascaris mystax*; and in 1853 Keber‡‡ observed the actual entrance of the spermatozoon into the egg of the common mussel.

* By far the most elaborate account of the reproductive process in its general aspect is in Heusen's monograph, *Physiologie der Zeugung*, in Hermann's *Handbuch der Physiologie*, vol. vi.

† See Patrick Geddes' article, *op. cit.* Also, Hensen's article, Hermann's *Handbuch*, *op. cit.*, p. 114. Kölreuter's paper appeared in *Mem. de l'Acad. d. St. Pétersbourg*, 1809.

‡ Jacobi, *Gledisch's Abhandlung d. Berlin Acad.*, 1764.

§ Spallanzani, *Versuch über d. Erzeugung d. Thiere u. Pflanzen*. German Trans. by Michaelis, 1786.

|| Prevost and Dumas, *Ann. d. Sciences Naturelles*, vol. iii.

¶ Martin Barry, *Phil. Trans. Roy. Soc.*, 1843.

** Leuckart, *Archiv. f. Anat. und Phys.*, 1855.

†† Henry Nelson, *Phil. Trans. Roy. Soc.*, 1852.

‡‡ Keber, *Ueber den Eintritt der Samenzellen in das Ei*. Königsberg, 1853.

The student was attracted by the attraction of Bartsch and whose researches into the development of the egg were of great value and it was one of our own in its development. In 1875 the late Dr. James Thomson whose scientific work is well known as a biologist and zoologist in this place. It was supposed that the fertilization of the egg was a simple process and it was supposed that the fertilization was a simple process which resulted in the formation of the embryo. It was supposed that the fertilization of the egg was a simple process and it was supposed that the fertilization was a simple process which resulted in the formation of the embryo. The first two observations were made in the eggs of the embryo and in 1875 when Bartsch made the observation of the fertilization of two nuclei in the embryo and in 1875 when Bartsch made the observation of two nuclei in the embryo and in 1875 when Bartsch made the observation of two nuclei in the embryo. At other times in 1875 Bartsch made a similar observation of the eggs of two other worms—*Ascaris macrura* and *Ascaris macrura*—without knowing of Bartsch's description. Bartsch followed up his work in 1875 by discovering the same phenomenon in the eggs of the gastropods—*Lymnaea stagnalis* and *Lymnaea stagnalis*. He also noticed in the eggs of these molluscs a peculiar fertilized appearance such as occurs in connection with the division of nuclei. These investigations were quickly followed by those of O. Hertwig, Ed. von Benedek and Fol. It is to be observed that Bartsch did not explain the origin of the second nucleus which he had observed in the fertilized egg. This was accomplished by O. Hertwig when in 1875 he published his researches on the development of *Tricampus bivalvus* in connection with the fertilization of the egg. He has

* Bischoff, *Entwicklung der Kanarienvogel*. 1843.

† Allen Thomson, Art. Comm. in Ind. & Sympoedia

† Bartsch. Beitrag zur Kenntnis der Insekten der Semaliden. Nov. Acta
Linn. Carol. 1873.

§ Auerbach Organometallische Studien. Breslau 1874.

1 Butschli, *Zrit. i. w. Zool.*, 1875.

90. Hertwig. Beiträge zur Kenntnis der Bildung, Befruchtung und Theilung des Thierischen Eies. Morph. Jahrb., 1875; also, Morph. Jahrb., 1877, 1878; also, in his most recent book, Lehrbuch der Entwicklungsgeschichte der Menschen und der Wirbelthiere. Erste Abth., Jena, 1886.

** E. van Beneden, *La maturation de l'œuf, la fécondation, et les premières phases du développement embryonnaire des mammifères*. Bull. Acad. Roy. de Belg., 1875; also, Bull. Acad. Roy., 1876; and especially his great work, *Recherches sur la Fécondation*, op. cit. The latter work has a bibliography, p. 417.

† Fol, *Sur le phénomène intimes de la fécondation*, *Comptes rendus*, *Per.* 1877; *Comptes rendus*, Oct., 1876; *Archiv. der Sc. Phys. et Nat.*, 1877; *Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève*, 1879.

the merit of demonstrating that the second nucleus was the head of the spermatozoon. Further, O. Hertwig at first supposed that the other nucleus was the germinal spot of Wagner set free by the destruction of the germinal vesicle. This error was pointed out by Van Beneden, and O. Hertwig accepted the correction, with the result that the other nucleus was soon shown to be, as Bütschli had previously conjectured, the germinal vesicle. The distinguished Belgian naturalist, E. van Beneden,* early recognised the importance of these observations. In 1875 he described the fusion of the nuclei, and expressed the opinion that in the fusion of the two nuclei there was a phenomenon comparable to the conjugation of the Protozoa and Protophyta; and in his magnificent monograph on the fecundation of *Ascaris megalocephala* (1883) he has largely advanced our knowledge of the subject. Although the entrance of the spermatozoon had been previously observed, no specific changes were immediately noticed. This was reserved for Fol,† a Swiss naturalist, who, in 1877, observed the entrance of the spermatozoid into the eggs of *Asterias glacialis* (a star fish), and of various species of *Echinus* (sea urchins), and he studied and figured the phenomena that ensued. These observations have been confirmed by many naturalists. (Fig. 14.)

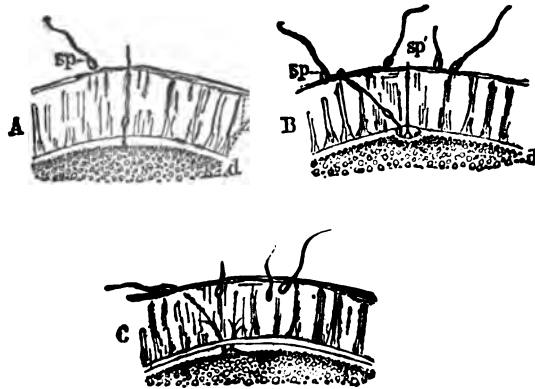


Fig. 14.—Fecundation of the eggs of *Asterias glacialis*, sp., Spermatozoon. The spermatozooids are in the mucus covering the egg. At A a spermatozoid has reached the periphery of the yolk. At B several are moving onwards towards a prominence in the surface of the yolk. At C the heads of one or two spermatozooids have united with and penetrated into this prominence. (Fol.)

* E. van Beneden, *op. cit.* † Fol, *op. cit.*

Another series of phenomena has been brought to light.* It is well-known from the researches of Strasburger and others that in the development of the reproductive organs of plants certain portions of the matter that is devoted to the formation of spores, antherozoids, and oospheres, or ova, are not used for that purpose, but are extruded or otherwise held aside from taking part in the reproductive process. Thus, in the sporangium of many fungi, a part of the protoplasm, called the *cytoplast*, remains over after the formation of the spores. In the development of the zoospores of algae, a part of the protoplasm, not used up, is extruded in the form of a vesicle from the sporangium, and in some cases, Strasburger states that just before the division of the spore-mother-cell a mass of stuff is extruded from the nucleus, called the *paranucleolus*. Similar phenomena have been observed in sexually-reproductive cells. The male element of mosses, the antherozoid, has an appendage attached to its posterior end. This appendage or vesicle has been found to be the "unused protoplasm of the mother-cell," along with actually a portion of the nucleus, which is thus excluded. In the angiosperms, during the development of the nucleus and the protoplasm of the pollen grain (the male portion) cell-like bodies are formed which are separated from the generative cell. Similar phenomena are noticed in the development of the female structures or *gametes*, that is to say, portions of protoplasm are extruded from the oogonium. Even in angiosperms, nuclear divisions take place in connection with the development of the oosphere or ovum. Thus, to quote from Dr. Sydney Howard Vines†:—"The nucleus of the young embryo-sac divides into two, one of which travels to each end of the sac; each nucleus then divides, and each of the two nuclei divides again, so that there is a group of four nuclei at each end of the embryo-sac. Of those at the micropylar end, one becomes the nucleus of the oosphere, two the nuclei of the synergids, and the fourth (polar nucleus), which is the sister nucleus of that of the oosphere, travels towards the middle of the sac, where it fuses with one of the chalazal nuclei, which has likewise travelled towards the middle of the sac, to form the definitive nucleus of the embryo-sac. It may be suggested that the division which

*I have derived special information on this point from the admirable *Lectures on the Physiology of Plants* by Sydney Howard Vines, M.A., D.Sc., F.R.S. Cambridge University Press, 1886.

†Vines, *op. cit.*, p. 641.

leads to the formation of the nucleus of the oosphere, and of the so-called polar nucleus, is the one which we are seeking; in that case the so-called polar nucleus would be the polar body." It appears, therefore, that in the development, both of non-sexual spores and of male and female elements in plants, a portion of the original nuclear substance is extruded or thrown aside and takes no share in the reproductive process. The portions thus laid aside or extruded have been called *polar bodies*. It is remarkable that analogous phenomena occur in the development of the ova and of the sperm cells of animals.

The extrusion of minute particles of matter, or polar bodies, from the egg was first observed by Dumortier* in the egg of *Lymnaea stagnalis* in 1837, and the phenomenon was investigated by F. Müller† in 1848. No relation between these bodies and the germinal vesicle was noticed until the researches of Bütschli, in 1875, to which I have previously referred. He observed a curious spindle-shaped structure passing between the germinal vesicle and the surface of the ovum. In 1876 Ed. van Beneden detected the extrusion of two polar bodies from the egg of *Asteracanthion rubens*. The researches of Fol, Selenka, and O. Hertwig not only corroborated these observations, but many details of the phenomena connected with their formation and extrusion were observed. Thus Calberla noticed that changes occurred in the germinal vesicle along with the extrusion of the polar bodies, and that these bodies might be eliminated even before the egg reached its maturity. In the great majority of cases the formation of the polar bodies preceded the union of the sexual elements, and researches by Fol and others have shown that the genesis of these bodies is independent of fecundation.

Let us now examine what actually occurs.‡ When the ovum is ripe, it consists, as already described, of a cell wall inclosing contents, in which are embedded the nucleus or germinal vesicle, in which again is the nucleolus or germinal spot. Previous, then, to actual fecundation (although the spermatozoid may have penetrated the ovum), a fusiform body is seen (the "direction-spindle"

* B. Dumortier, *Memoire sur l'embryologie des mollusques*. Brussels, 1837.

† Fr. Müller, *Archiv. f. Naturgesch.*, 1848.

‡ J. T. Cunningham has given an excellent account of E. van Beneden's *Researches on the Maturation and Fecundation of the Ovum* in *Quart. Jour. of Micros. Science*, 1885.

of Bütschli, and the "amphiaser of rejection" of Fol), as was first described by Bütschli, stretching from the germinal vesicle (Fig. 15)

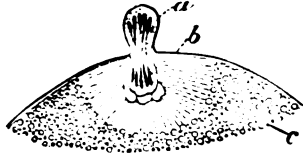


Fig. 15.—Extrusion of a polar body from the egg of a snail, *Succinea Pfeifferi*. *a*, Polar body showing elongated filaments of nuclear matter; *b*, radiated appearance around the polar body; *c*, yolk. (Bütschli.)

towards the surface of the ovum, so that one end of the spindle touches the surface whilst the other is in contact with the germinal vesicle. At the same time, or rather immediately before the appearance of the spindle, the wall of the germinal vesicle becomes less and less distinct, and the protoplasm in its immediate vicinity assumes a radiated appearance. There is every reason to believe that a portion of the substance of the germinal vesicle forms part of the spindle. By-and-by a small globule, protruding from the surface of the ovum, appears at the external end of the spindle. This is the first polar body. In most cases a second spindle is formed, and there is the extrusion of a second polar body. Bütschli thought that the spindle was entirely extruded in the polar body, but Fol and Hertwig have shown that this is not the

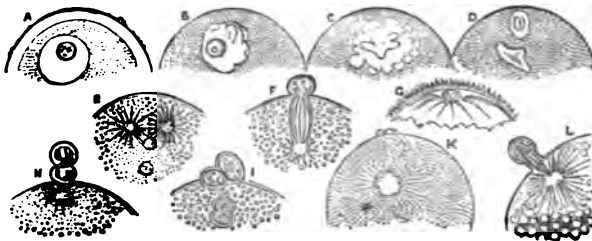


Fig. 16.—A ripe ovum of *Asterias glacialis* with excentric germinal vesicle and spot; *B, C, D, E*, gradual metamorphosis of germinal vesicle and spot; *F*, detachment of first polar body and withdrawal of remaining part of nuclear spindle within the ovum; *G*, portion of living ovum with first polar body; *H*, formation of second polar body; *I*, after formation of the same, showing the remaining internal half of the spindle in the form of two clear vesicles; *K*, ovum with two polar bodies and radial striae around female pronucleus; *L*, expulsion of polar body (*A—K*, after Fol; *L*, after Hertwig). (*P. Geddes*.)

case. As to the genesis of the spindle itself, there is still considerable difference of opinion. Bütschli conceived that the fibres of the spindle were formed by the coalescence of granules. Föl described them as due to a swollen condition of the "filaments bipolar," meaning certain filaments passing from the germinal vesicle towards each pole of the egg. O. Hertwig supposes that they arise from the fragments of the wall of the germinal vesicle and of the germinal spot; and these views of Hertwig have been supported by Trinchese and Blochmann. (Fig. 16.)

Considerable discussion has taken place as to whether these phenomena belong to the class of changes occurring in karyokinesis. Flemming, in 1882, after a careful study of the egg by the methods followed in the observation of karyokinesis, came to the opinion that the phenomena are the same, with this difference, that in the egg the chromatin element does not bulk so largely as the achromatin constituent, the result being that in the karyokinesis of cells the chromatin figures are the most apparent, whereas in the egg the achromatin figures arrest the attention. This view is well illustrated by the figures of ordinary karyokinesis given by Rabl (Fig. 17), in which the achromatin spindle-like figures are very

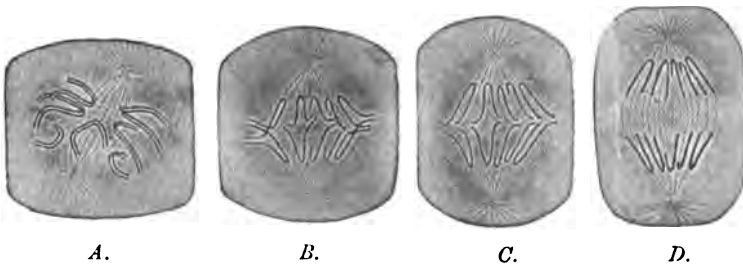


Fig. 17.—Diagram showing the mode of nuclear division. *A* shows strongly marked chromatin filaments with the spindle figure. At the ends or points of the spindle observe the star shaped or radiating arrangement of the protoplasm, and in the middle of the spindle the chromatin filaments. In the latter a longitudinal division of the filaments has already begun. *B* shows the number of chromatin filaments multiplied by division and beginning to be arranged with the loops in the same direction as the spindle. *C* shows the loops still more regularly arranged. *D*, both groups of the filaments or loops have retreated towards the poles of the spindle. (*Rabl*.)

distinctly shown; on the other hand, as E. van Beneden points out, Hoffmann is the only observer who has described the spindle in the mammalian egg, whilst he himself has looked for it in vain,

and he inclines to the view that the extrusion of the polar body is not an example of ordinary karyokinesis, in which the ovum may be regarded as simply dividing, so that one half is the minute polar body, whilst the other half is the rest of the ovum, but that it is really a physiological process peculiar to the ovum. In the development of the egg of *Ascaris megalocephala*, E. van Beneden describes a peculiar figure termed by him the ypsiliform figure, from its resemblance to the Greek letter Y. (Fig. 18.) It may

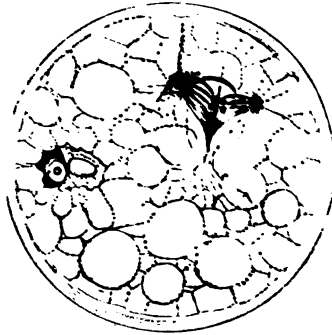


Fig. 18.—Egg of *Ascaris megalocephala*, showing the Y-shaped figure, having delicate protoplasmic filaments connected with it. The altered spermatozoid is seen on the left hand portion of the egg. (E. van Beneden.)

be compared to the toy known as a "cup and ball," the stalk of the cup being the vertical portion of the Y, and supposed by Van Beneden to be like a thread or cord, whilst the two diverging limbs are really sections of the sides of the cup. In the hollow of the cup there is a mass of clear homogeneous matter, containing chromatin globules, corresponding to the ball in the well-known toy. The fibrils of the Y-shaped body originate in fine granules, which are the remains of the membrane of the germinal vesicle, along with some of the surrounding protoplasm. At the end of each limb of the Y there is also a little mass of granules, and around the stem of the Y, and running up so as to assist in forming the cup, there is a clear transparent mass, to which he gives the name of *prothyalosome*. The axial fibres, those forming the stem of the Y, appear first. Thus, in the first instance, a fusiform figure appears, the pointed ends corresponding to the ends of the stem of the Y. Next, two other centres of attraction appear in the prothyalosome, like two stars or radiant

points, the fibrils from each of which coalesce at the upper end of the stem of the Y, thus giving rise to the Y-shaped figure. At first the Y-shaped figure is near the centre of the ovum, but it gradually approaches the periphery, and the point of each limb of the Y touches the vitelline surface, although not at the same time. (Figs. 19, 20, 21.) The form of the Y then changes

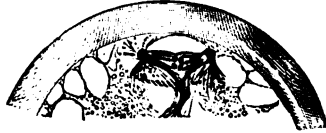


Fig. 19.—Shows Y-shaped figure near the surface, with the upper limbs of the Y flattened out so as to make the figure T-shaped. Observe also the transverse striae. Egg of *Ascaris megalocephala*. (E. van Beneden.)



Fig. 20.—The upper part of the Y-shaped figure has now reached the surface of the egg, or stage prior to the genesis of the first polar body, which is formed by transverse cleavage. Egg of *Ascaris megalocephala*. (E. van Beneden.)



Fig. 21.—Formation of the first polar body in egg of *Ascaris megalocephala*, indicating one of the last modifications of the Y-shaped body. (E. van Beneden.)

in consequence of fibres in the two limbs uniting transversely, so that it becomes more homogeneous in appearance; but at each point corresponding to the free end of the limb of the Y there is a little star-shaped cluster of chromatin granules. As the Y-shaped body approaches the surface, the stem of the Y lengthens, and the fibres become less and less distinct, and at the lower end the matter forming the head of the spermatozoid is apparent. The first polar body is formed of a portion of the chromatin stars at the ends of the limbs of the Y, along with a portion of the clear matter surrounding the limbs and forming the cup—the prothylosome; and E. van Beneden attaches great importance to the fact that division does not occur so as to cut the pole (that is to say, the limb of the Y, with surrounding matter) transversely, but the division takes place equatorially, just as if the limbs of the Y had opened

out, and each limb had been cut in the direction of its length. In all cases of ordinary karyokinesis the cleavage always takes place transversely to the direction of the filaments of the spindle, and if we recognise the Y-shaped figure of E. van Beneden as being formed of two spindles, the importance of his observation will be appreciated. The formation of the polar globules cannot therefore be deemed an example of karyokinesis: at all events, it is not of the usual type. After the removal of both the polar bodies, the portions of the chromatic stars or discs, along with the neighbouring portions of the prothyalsome, unite to form a body, which is in all respects similar to the polar bodies extruded. This he terms the *deuthyalosome*.

This body, the deuthyalosome, may be regarded, then, as formed of the remains of the germinal vesicle. The vesicle, by this elaborate process—which occurs *before* fecundation, although it may be going on while the spermatozoon is in the egg,—has thrown off a portion of itself, and the body which remains at the end of the process cannot be regarded, morphologically or physiologically, as an ordinary cell nucleus.

Now we approach true fecundation. It has been ascertained that one single spermatozoon is sufficient for the process. Entering the ovum, either by a distinct aperture (in the ovum), termed the *micropyle* (Fig. 22), or where no special aperture has been observed

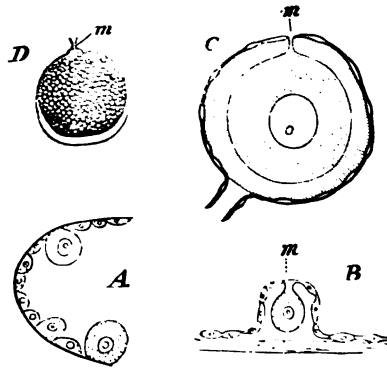


Fig. 22.—A, Blind end or *cul-de-sac* of the ovary of a star fish. B and C, Development of the egg of *Holothuria Bohadschia*, after Semper. B, Young egg with the surrounding epithelial cells detached; at *m*, the opening of the micropyle. C, Ripe egg, showing a thickened zona pellucida, and the epithelial cells much elongated; *m*, micropyle, very narrow. D, Egg of *Unio*, showing micropyle at *m*. (Hensen.)

through the cell wall, it quickly undergoes chemical and physical changes. It becomes more susceptible of the action of colouring matters, and instead of being granular it assumes a homogeneous appearance. The tail disappears, and the head becomes globular in form. E. van Beneden has observed in many eggs a refringent globule, similar in appearance to a body seen in the spermatozoid, and he has no doubt that this body has been thrown off by the spermatozoid, and finally ejected from the egg itself, probably with the second polar body. This important observation is of profound significance, as showing that the spermatozoid (as well as the germinal vesicle) gets rid of a part of its substance (*seminal granule*) before fecundation occurs.*

Next comes the protrusion of the second polar body, which is formed from a portion of the deuteryalosome. E. van Beneden states that between the times of the expulsion of the first and of the second polar body, the egg mass rotates through a variable angle, so that the second polar body is not extruded at the same point on the vitellus as the first. Further, he states that in consequence of this rotation, say of 90° , while the axis of the spindle of the first polar body corresponded with the axis of the egg, the axis of the spindle of the second polar body is perpendicular to that axis, or is in the line of the equator of the egg. Again, he observes that, in the extrusion of the second polar body, the cleavage takes place in the direction of the filaments of the aster, not transversely.

The body left in the egg after the formation of the two polar bodies is termed the *female pronucleus*, while that formed by the head of the spermatozoid is the *male pronucleus*. Until the second polar body has been extruded, the spermatozoid remains inactive, but when this has occurred a series of changes ensues.

* Further, E. van Beneden and Ch. Jahn have discovered the expulsion by the spermomere of a minute globule, which does not therefore enter into the formation of the spermatozoid. *La spermatogenèse chez l'ascaride megalocephale*, Bull. de l'Académie Royale de Belgique, 1884. The separation of a globule has also been described by J. E. Blomfield: *On the Development of the Spermatozoa*, part I, *Lumbricus* (Earth-worm), Quart. Journ. of Microsc. Science, 1880. See also on this question Herbert H. Brown's paper on *Spermatogenesis in the Rat*, Quart. Journ. of Microsc. Science, 1885, in which Prof. Ray Lankester's opinion is given as regards the globule in case of the earth-worm.

which ends in the division of the first cell of the embryo into two cells. (Figs. 23 and 24.)

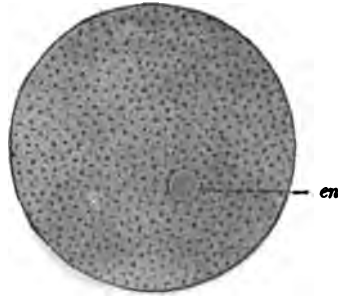


Fig. 23.—Ripe egg of a sea urchin (*Echinus*). *en*, Egg nucleus, or germinal vesicle. (O. Hertwig.)

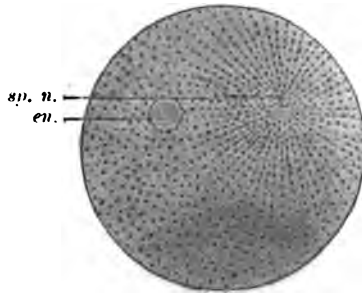


Fig. 24.—Fecundated egg of a sea urchin. The head of the spermatozoid, constituting the spermatozoid nucleus, *sp.n.*, or male pronucleus, is surrounded by radiated protoplasm; *en*, egg nucleus, or female pronucleus. (O. Hertwig.)

The female pronucleus is now a nucleus containing two chromatin filaments, or loops, originally derived from the germinal vesicle of the egg. It is very curious to find that the number of loops seen in the various stages of these processes is very constant. Thus, in the germinal vesicle there are two chromatin plates, each composed of four chromatin globules; the same in the Y-shaped figure; in the first polar body two chromatin bodies, each formed of two smaller ones; in the deuthyalosome, two chromatin filaments, each dividing into two; the same in the second polar body; and now in the female pronucleus again two chromatin loops, each formed of two smaller portions.

The male pronucleus is formed from the head of the spermatozoid,

and it also contains two portions of chromatin. It is found near the lower pole of the egg.

The two pronuclei approach each other and ultimately unite. According to O. Hertwig, Fol and Mark, there is a complete fusion. This is fecundation, the union at last of the two elements. (Figs. 25 and 26.)



Fig. 25. Fertilized egg of a sea urchin. Spermatozoal nucleus, or male pronucleus, on egg nucleus, or female pronucleus. The two pronuclei are close together and are both surrounded by a radiated mass of chromatin.

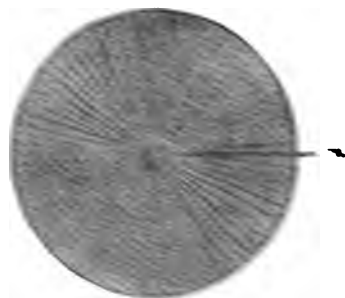


Fig. 26. Fertilized egg of a sea urchin after fertilization. The female pronucleus is now the egg nucleus, and the male pronucleus is now the spermatozoal nucleus. The spermatozoal nucleus has a radiated chromatin.

The two pronuclei are now the spermatozoal nucleus and the female pronucleus. The female pronucleus is now the egg nucleus, and the male pronucleus is now the spermatozoal nucleus. The spermatozoal nucleus has a radiated chromatin.

and female elements. He divides the process into four stages :—
 1st. The four chromatin filaments increase in size and become coiled to a greater or less extent. It is to be remembered that two have been supplied by the male and two by the female pronucleus. 2nd. The contours of the pronuclei become less and less distinct; each chromatin loop divides transversely in the middle, so that there are now eight loops, and the eight loops of chromatin move so that the shut end of each loop is directed towards the equator of the fecundation nucleus. Imagine an orange with eight loops of cord placed equatorially in it, the ends directed towards the axis passing from pole to pole. 3rd. Each loop is then divided longitudinally, thus giving rise to sixteen loops, and the two groups of eight are separated by a thin layer of matter. 4th. Each of these groups of eight are now situated in what E. van Beneden terms sub-equatorial planes, parallel, of course, with the equator. (Figs. 27, 28, and 29.)

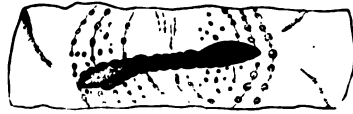


Fig. 27.—Arrangement of chromatin filaments in the equator of the egg of *Ascaris megalocephala*. The filaments are the dark irregularly-shaped bar. Only the middle portion of the egg is shown. (*E. van Beneden.*)

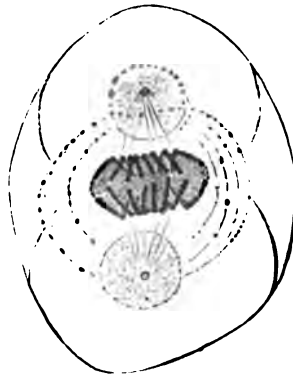


Fig. 28.—Stage in the division of the egg of *Ascaris megalocephala*, showing the chromatin loops separating into two sets and retreating from each other. (*E. van Beneden.*)

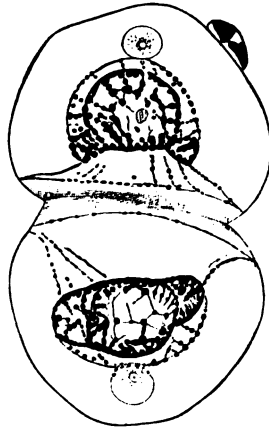


Fig. 29.—Stage of division of the egg of *Ascaris megalocephala*, showing the breaking up of the chromatin threads into minute globules, giving in some places a reticulated appearance from the crossing of short filaments. (*E. van Beneden.*)

Thus it is evident that each loop has given a half of its substance to each of the daughter nuclei, and as there was an equal number of loops from the male and female portions to start with, it follows that each daughter nucleus must have male and female elements. The two sets of loops recede towards the poles of the nucleus, and then there is division of the body of the yolk, according to the ordinary method of karyokinesis already described. Further, the two cells thus formed, nourished by the fluids in which they exist, increase in size, and again divide karyokinetically into four. The process is repeated over and over again so as to form the primitive cells from which all the tissues and organs of the body are derived ; and if the karyokinetic division is repeated so that portions of the chromatin derived from the male and female

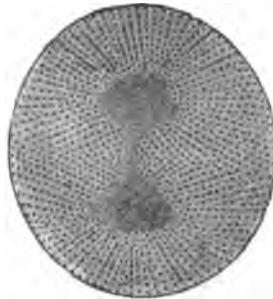


Fig. 30.—Egg of a sea urchin preparative to cleavage. (*Hertwig.*)

elements (multiplied and increased in quantity of nutrition, but the same in kind) are divided equally it follows that all cells contain equal quantities of matter related to the male and to the female parent; and, to crown all, according to this view, each living cell is a hermaphrodite being.* (Figs. 30, 31, 32, 33.)



Fig. 31.—Egg of sea urchin at moment of division, showing constriction of the protoplasm at right angles to the axis of the nucleus. (*Hertwig.*)



Fig. 32.—Egg of sea urchin after division. Observe the nucleus in each half. The streaked appearance of the protoplasm begins to be less distinct. (*Hertwig.*)

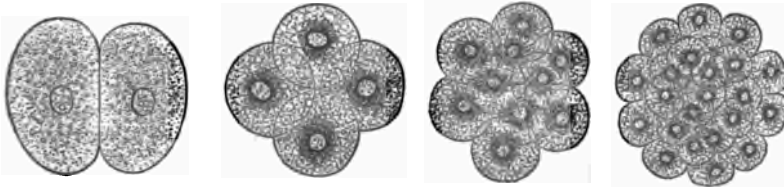


Fig. 33.—Various stages of the cleavage of the egg to form embryonal cells. (*Gegenbaur.*)

* This view is associated with the name of Professor Sedgewick Minot of Harvard. "*Science*," vol. iv., 1884. Also *Proceed. Boston Society of Natural History*, 1877.

Such, then, is the wonderful story of the origin of the cells and of the living matter that forms our bodies. One is naturally inclined to ask—Does a knowledge of these phenomena throw any light upon the well-known facts of hereditary transmission? Not a few theories of heredity have been advanced. The oldest of all is that the soul of an ancestor entered the body of a newly-born being and made the body like that in which it had at one time existed. The theory of the transmigration of souls may be traced to very remote times, and it exists almost unmodified in the opinions of some of the so-called savage races of the present day, races probably representing, however, not the primitive type of thought and practice, but opinions modified in the course of ages, like those of the higher and civilised races. Stahl, in accordance with his mystical views, held that the soul formed the fœtus and shaped it according to the paternal or maternal type. Then, in our own day, came the doctrine of Pangenesis of Charles Darwin,† which assumed the existence in all cells of small corpuscles which circulate free in the body. These gemmules are transmitted by the parents, and they are usually developed in the next generation, but may lie dormant for generations, and their evolution depends on their union with gemmules of a kindred nature, supplied from another organism. This theory is capable of explaining many of the facts, but it labours under the disadvantage that there is no vestige of proof of the existence of such gemmules.

Haeckel‡ has endeavoured to solve the problem by supposing that what is transmitted is not matter but a certain kind of molecular movement which the tissues acquire by constant repetition, and retain by a kind of unconscious memory. Heredity, according to this view, would depend on the more or less accurate transmission of special kinds of molecular movement, while variability would be caused by the action of external agencies

* Ch. van Bambeke, *Pourquoi nous ressemblons à nos parents?* *Bull. de l'Académie Royale de Belgique*, 3^{me} série, tom. x., 1885. This is an admirable résumé of recent speculations.

† Charles Darwin, *On the Variation of Plants and Animals under Domestication*, 1867, chaps. xxxvii. and xxxviii. See also in this relation, Herbert Spencer's *Principles of Biology*, vol. i., chaps. iv. and viii. Also, Sir Richard Owen's work on *Parthenogenesis*, 1849. It is interesting also to read Professor Owen's criticism of Pangenesis in his *Comparative Anatomy and Physiology of Vertebrates*, vol. iii., p. 813.

‡ Haeckel, *Die Perigenesis der Plastidule oder die Wellenzugung der Lebenstheilchen*. Berlin, 1876.

changing more or less the character of the movement so transmitted. The obvious criticism on this theory is, that we as yet know far too little of the character of molecular movements, to make our knowledge the basis of any such theory.

Nägeli* rejects both the theory of Pangenesis of Darwin and the theory of Perigenesis of Haeckel, because the one calls in the aid of hypothetical germs and the other of hypothetical movements, and he endeavours to establish a theory on the basis of fact. Protoplasm, according to him, consists of two portions, one, fluid, called *hygroplasm*, and the other solid or insoluble, *stereoplasm*. The stereoplasm, however, is partly nutritive, but the other portion, called *idioplasm*, is the seat of all active changes. This idioplasm ramifies through the body, is in every cell and tissue; and each tissue has its own kind of idioplasm, so that there is a vast variety of idioplasms, differing, however, more dynamically than in any detail of structure. Reproductive cells contain idioplasm that has returned from the condition of somatic idioplasm to the state of the idioplasm of the germ from which the organism sprang. Further, he supposes that the specific properties of the idioplasm depend on the grouping of more minute particles, the *micellæ*, and that this grouping is more complex in the idioplasm of the higher beings than it is in the lower. Suppose, then, that each parent transmits an equal portion of idioplasm, there will be an equal transmission of the peculiarities of each parent; and if one idioplasm predominates, the balance may lean to the side of the father or of the mother. This mass of idioplasm, as already said, extends through the body, having subsidiary characters peculiar to each kind of cell, but always carrying with it the more special peculiarities which it had at first. During growth it retains all its specific characters, and the germ cell is simply a cell containing idioplasm, having chiefly the primitive character. As, however, the somatic idioplasm is influenced by external conditions, to some extent, and as the return of the somatic idioplasm to the state of germinal idioplasm is not always exact, the offspring never exactly resemble their parents. Hence arises variability.

But while this theory is founded on the fact that there is a kind of all-prevalent matter—the protoplasm,—it is liable to the same objection as was advanced to the other two theories—it is

* Nägeli, *Mechanische-Physiologische Theorie*, 1884.

too conjectural. The question is—Where is this idioplasm? If it is the reproductive matter, it must exist in many cells, more especially in those which yield the male and female elements. That it does exist in certain cells of plants is evident from the fact that cuttings produce roots, and when a stem is cut across new shoots appear from the lateral buds. Almost any part of the leaf of a *Begonia*, if suitably planted, will give origin to a fully-formed plant. Similar phenomena may be observed in certain animals—more especially in amphibians. If the limb of a Salamander be removed, the limb may be renewed, that is to say, the cells forming the various tissues of the stump possess the power of producing cells of the same kind, and of rebuilding the limb. This has been aptly compared by Pflüger* to the growth of a crystal. A crystal of alum has a certain molecular structure, and if a small fragment of such a crystal be placed in a saturated solution of the same salt, the broken fragment is repaired, so as to form the perfect crystal. This is more than an analogy. The molecular processes of the crystal are the cause of the deposition of the particles of alum in such an order as to renovate the crystal; and, in like manner, the molecular processes in the cells of the outermost layer of the stump lead to the formation of new cells of the same kind out of the material furnished by the blood plasma in their vicinity.

Seizing hold so far of Nägeli's idea, Strasburger† has modified it, and made the position more intelligible. Like him, he considers protoplasm as consisting of two substances, a nutritive hyaloplasm, and a formative hyaloplasm; but he identifies the formative hyaloplasm with the chromatin filament of the nucleus, which we have already studied. This substance he calls nucleoplasm or nucleo-hyaloplasm. It is the active substance in the nucleus, and even in the protoplasm around the nucleus, as Goodsir long ago stated. All the metabolic changes in the cell substance are controlled and directed by the nucleo-plasm. Strasburger states that the reproductive power of a cell depends on it being in the embryonic state, and in plants reproductive cells in this sense are not uncommon, seeing that many parts of plants are capable of vegetative reproduction.

* Pflüger, *Ueber den Einfluss der Schwerkraft auf die Theilung der Zellen und auf die Entwicklung der Embryo*, *Archiv. f. Physiol.*, vol. xxxii.

† Strasburger, *Neue Untersuchungen über den Befruchtungsvorgang bei den Phanerogamen als Grundlage für eine Theorie der Zeugung*. Jena, 1884.

This view throws light upon the phenomena of the expulsion of polar bodies from the ovum, and from the spermatozoid substance. These phenomena express the return of the cells to their embryonic conditions. The late F. M. Balfour held that the extrusion of the polar bodies from the ovum, or rather the extrusion of a part of the germinal vesicle, was "requisite for its functions as a complete and independent nucleus, . . . to make room for the supply of the necessary parts to it again by the spermatoc nucleus. My view," he says, "amounts to the following, viz.:—that after the formation of the polar cells, the remainder of the germinal vesicle, with the ovum (the male pronucleus), is incapable of further development without the addition of the nuclear part of the male element (spermatozoon), and that if polar cells were not formed parthenogenesis might normally occur. A strong support for this hypothesis would be afforded were it to be definitely established that a polar body is not formed in Arthropoda and Rotifera, since the normal occurrence of parthenogenesis is confined to these groups. It is certainly a remarkable coincidence that they are the only two groups in which polar bodies have not so far been satisfactorily observed." Further he says:—"The function of forming polar cells has been acquired by the ovum for the express purpose of preventing parthenogenesis."*

This notion, which has been somewhat modified by various authors, and is refused by Carnoy as an explanation, is that the extrusion of the polar bodies from the nucleus of the ovum is the removal of the male idioplasm; so that what is left is truly female, and the extrusion of the particle from the spermatozoid is the removal of the female idioplasm, so that what remains is truly male. The female idioplasm would thus transmit peculiarities of

* F. M. Balfour, *Comparative Embryology*, vol. i., p. 72. It is only right to note that this theory is strongly opposed by Carnoy, and that he especially disputes the correctness of the interpretation of the extrusion of the polar bodies, *La Cytodierèse de l'œuf, La Cellule*, tome iii., fasc. i., p. 60. It is also asserted that Weismann has seen polar bodies extruded from the eggs of certain crustaceans that are parthenogenetic (Weismann, *Richtungskörper bei parthenogenetischen Eiern*, *Zool. Anz.*, 27th Sept., 1886). Even if this be the case it does not seem to me to destroy the validity of Balfour's theory, but only to show that it is less extensive in its application. The extrusion of polar bodies by parthenogenetic ova may be the survival of an ancestral habit, and possibly after removal of the polar body there may still be enough of the male matter left to allow of development going on, without the entrance of a fresh spermatozoid. (For further remarks on this subject see p. 50.)

the mother, whilst the male idioplasm would send on those of the father. But, as Strasburger and Kölliker acutely remark, the mother transmits not only her own peculiarities, but also those possibly of the maternal grandfather and of the maternal great-grandfather; and, on the other hand, the father may send onwards traits of the paternal grandmother and of the paternal great-grandmother. The maternal idioplasm cannot therefore be regarded as entirely female, nor the paternal as entirely male. Strasburger holds that the nucleo-idioplasm filament may be regarded as made up of a number of segments derived from previous generations, and that in certain circumstances one portion may influence the kytoplasm of the ovum more than the other, thus giving rise to a manifestation of some of the hereditary qualities of the particular generation to which the portion of nucleohyaloplasm corresponded. It appears to me that here Strasburger passes entirely into the region of theory. The one statement of importance in his theory is the identification of the idioplasm of Nägeli, or, as he terms it, the nucleohyaloplasm, with the chromatin filament. It is at this point that the important observations of E. van Beneden come in with great effect. If it be the case that the chromatin filaments from the male and those from the female remain distinct, and are communicated in equal amounts to the nuclei formed by the division of the fecundation nucleus, and if this process be multiplied indefinitely in the formation of the cells of the body, we see that each cell is representative of both father and mother, to a greater or less extent, according to the amount of maternal and paternal idioplasm present. (Fig. 34.) Further, it is necessary to assume that this idioplasm is

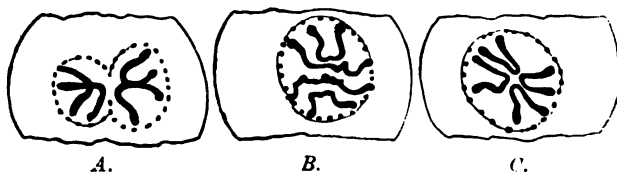


Fig. 34.—Different arrangements of the primary chromatin loops in the equatorial plane of the egg of *Ascaris megalocephala*. (E. van Beneden.)

capable by nutrition of being increased in quantity, but by the action of surrounding conditions it may be acquiring properties peculiar to itself, giving rise to the individuality of the person in whose body these changes are supposed to take place. A time comes, however, when cells lose the power of thus multiplying

indefinitely by fission, the growth of the body is arrested, and the general characters of the individual are fixed. One can suppose, then, that if any cell in the body could get rid of its male portion of idioplasm, and if another got rid of its female portion, the two remaining parts might conjugate, and the process of cell division might start afresh. The stimulus would still be greater if the two idioplasms were more different than is likely to be the case if obtained from the cells of the same individual. The best effect would be produced if a certain amount of difference existed, and this is attained by the idioplasm of two individuals being brought into contact. May not this be the key to the advantage gained by sexual difference, and may it not explain the infertility that results if two idioplasms from two individuals too closely related be brought into mutual relationship? This rendering and expansion of Strasburger's theory I have reached after a careful consideration of the question in the light of the facts of modern investigation.

The peculiarity of Strasburger's view is that the object of the extrusion of the polar bodies is simply the attainment of the embryonic condition, and that the reproductive matter—call it idioplasm, or any name you choose—is formed by the conversion of somatic into reproductive idioplasm. In the latter statement Strasburger follows Nägeli. The essential distinction between Strasburger and Nägeli is that while the conceptions of the former are structural and material, those of the latter are dynamical. This supposed conversion of somatic into reproductive idioplasm is a difficulty, and a consideration of it has led Weismann* to promulgate the theory of what is termed the *continuity* of the germ-plasma. This view is that heredity consists in the transmission of a nuclear substance of special molecular structure, not the idioplasm of Nägeli, nor the nucleohyaloplasma of Strasburger (identical with chromatin), but a substance special and peculiar to the germinative cells. This nuclear matter, which he calls *Keimplasma*, germ-plasma, is passed on from generation to generation without alteration; it is therefore continuous and immortal if individuals do not fail in propagating their species. This specific germ-plasma, derived from the male and female parents, is not entirely used up in the development of the offspring, but a portion

* August Weismann, *Die Continuität des Keimplasma's als Grundlage einer Theorie der Vererbung*. Jena, 1885. See also an account of this memoir by Professor H. N. Moseley in *Nature*, vol. xxxiii., p. 154.

of it is set aside to form the germ-plasma of the next generation. According to this view, the germ-plasma is in no way derived from the somatic-plasma; each has an independent existence; but while the somatic-plasma cannot influence the germ-plasma, the portion of germ-plasma not laid aside to form the germ-plasma of the next generation exercises a potent influence over the development of the somatic-plasma, transmitting to it the characters of the parents. Professor Weismann supports this view with many striking illustrations, and he adapts the theory to the explanation both of the extrusion of polar bodies and of parthenogenesis. Thus the ovum has two kinds of plasma in it, histogenetic or somatic-plasma and true germ-plasma. In its early stages the histogenetic plasma is engaged in forming the yolk and membranes, and as it is of no further use in the further development of the embryo, it is got rid of in the form of one or more polar bodies to make room for fresh histogenetic plasma, derived in turn from the germ-plasma of the spermatozoon. The polar bodies are thus ovogenous nucleo-plasma, got rid of to allow new nucleo-plasma to have free play. A similar explanation applies to the separation of particles from the male sperm cell.

As to parthenogenesis, Weismann supposes, in the first place, that the male and female elements in fecundation, that is to say, the germ-cell and the sperm-cell, are practically identical, and that after the extrusion of the polar bodies, development is started by the sudden addition to the so-called female element of the so-called male element. This sudden addition necessitates cleavage, and as nutrition goes on actively, for the same reason, cleavage goes on again and again to form the embryonic cells. In some ova, however (parthenogenetic ova), even after the extrusion of polar bodies, nutrition goes on so actively as to start the developmental process without the stimulus caused by the sudden addition of the so-called male element. Parthenogenesis, according to this view, is thus merely a modification of the power of growth. The theory is not open to the objection urged against that of F. M. Balfour, namely, the undoubted extrusion of polar bodies from, at all events, some parthenogenetic ova.

It appears to me, however, that this theory, so ably maintained by Weismann, whilst it undoubtedly removes some of the difficulties, leaves the facts of hereditary transmission unexplained. If the portion of germ-plasma not laid aside influences the development of the body, conferring on each tissue and organ at least some

of the proclivities of the parent—How does it do so? The molecular mechanism by which this is accomplished is inexplicable. On the other hand, if this germ-plasma does not so influence development, how are the facts of hereditary transmission to be explained? It is, I humbly think, quite possible that Weismann may be right in the conjecture that a portion of the original germ-plasma may be laid aside at the earliest period of development to constitute the germ-plasma of the next generation; but surely this germ-plasma has received a molecular imprint from the parent in whose body it at one time existed so that it transmits certain of the characteristics of that parent. If the germ-plasma cannot be altered, how are we to account for the transmission of special characters of any kind? Weismann has admitted this difficulty by denying the alleged transmission of acquired characters by sexual reproduction; but all characters must have been acquired at one time or another, and any organism is what it is at the present moment, in consequence of this transmission of acquired peculiarities, through countless generations. The germ-plasma cannot then remain the same, and therefore the only way in which we can suppose it to be modified is through the agency of the idioplasm throughout the body. This view will explain, to some extent at least, the transmission of acquired characters.*

In all these discussions one aspect of the subject, as it relates to the higher organisms, and especially to man, is often omitted; it is the influence which the female parent exerts on the development

* I have to express my admiration of Weismann's theory as a guide to experimental investigation. My thanks are due to Professor E. Ray Lankester for valuable criticisms of this portion of the present paper, and specially for directing my attention to the importance of Weismann's researches. Mr. J. H. Fullarton, M.A., B.Sc., has also read the whole paper and favoured me with his remarks. I would further observe that it can hardly be expected that acquired characters in their full intensity would be transmitted to the immediately succeeding generation, seeing that the ova destined to become the individuals of that generation are found in the ovary of the mother during embryonic life. The influence of an acquired character might have a certain effect on the ova during the life of the mother, but not enough to reproduce the acquired character with any degree of strength in the offspring. If the influences producing the acquired character acted also on the offspring, its effect on the offspring of the third generation would be intensified, and thus a process of accretion during several generations may be required to stamp acquired characters on offspring.

of the offspring, while in the uterus, in consequence of the intimate union that exists for a considerable period of time. It is a familiar observation that animals reared outside the mother's body, as in most invertebrates, in fishes, amphibians, and birds, are remarkably similar to each other. The individuals in a shoal of fish or a flock of sea gulls or sparrows can scarcely be distinguished. It is when we reach the stage of development by placental connection that we begin to observe diversity of appearance, and if along with this we suppose that, in consequence of a great development of the nervous system, the female becomes more and more susceptible of external impressions which react on her body and through her body on her offspring *in utero*, an explanation, so far, of individual peculiarities of the human race becomes apparent. There can be no doubt that pregnancy makes a remarkable change on the mother, to such an extent that the characters of subsequent offsprings may be influenced. Thus, it is well known to breeders of animals that a pregnancy induced by a certain kind of male may deteriorate the characters of offspring that owe their origin to subsequent impregnations by other males.* It is possible, therefore, that not a few maternal characters may arise in this way, and that if we could hatch human beings as we can hatch eggs, human beings might be so similar in appearance as to be practically indistinguishable.†

There is still one other view of the matter which I shall briefly notice. If the germinal vesicle be only the 1-500th of an inch, and the head of the spermatozoid be only the 1-6250th of an inch in diameter, dare we suppose, on purely physical grounds, that so small a particle of matter as is formed by the union of the two can contain a sufficient number of organic molecules to account in any way for the transmission of hereditary peculiarities? The late Professor Clerk Maxwell,‡ in his profoundly interesting article on the Atom in the *Encyclopædia Britannica*, thus states the case:—

"The first numerical estimate of a diameter of a molecule was that made by Loschmidt in 1865 from the mean path and the molecular volume. Independently of him, and of each other, Mr. Stoney, in 1868, and Sir W. Thomson, in 1870, published results of a similar kind—those of

* A. Harvey. 1. Relative influence of male and female parents; *Monthly Journal of Medical Science*, 1854. 2. On the fœtus *in utero*; Edinburgh, 1850. 3. *Fœtus in utero*; Glasgow, 1859.

† This is a profound subject, and is only touched lightly in the above paragraph, and I offer these remarks merely by way of suggestion.

‡ J. Clerk Maxwell. Article *Atom*, in *Encyclop. Britan.*, 9th ed.

“ Thomson being deduced not only in this way, but from considerations
 “ derived from the thickness of soap-bubbles, and from the electric action
 “ between zinc and copper.

“ The diameter and the mass of a molecule, as estimated by these
 “ methods, are of course very small, but by no means infinitely so. About
 “ two millions of molecules of hydrogen in a row would occupy a milli-
 “ metre, and about two hundred million million million of them would
 “ weigh a milligramme. These numbers must be considered as exceedingly
 “ rough guesses; they must be corrected by more extensive and accurate
 “ experiments as science advances; but the main result, which appears to
 “ be well established, is that the determination of the mass of a molecule
 “ is a legitimate object of scientific research, and that this mass is by no
 “ means immeasurably small.

“ Loschmidt illustrates these molecular measurements by a comparison
 “ with the smallest magnitudes visible by means of a microscope. Nobert,
 “ he tells us, can draw 4,000 lines in the breadth of a millimetre. The
 “ interval between these lines can be observed with a good microscope.
 “ A cube, whose side is the 4000th of a millimetre, may be taken as the
 “ *minimum visible* for observers of the present day. Such a cube would
 “ contain from 60 to 100 million molecules of oxygen or of nitrogen; but,
 “ since the molecules of organised substances contain on an average about
 “ 50 of the more elementary atoms, we may assume that the smallest
 “ organised particle visible under the microscope contains about two
 “ million molecules of organic matter. At least half of every living
 “ organism consists of water, so that the smallest living being visible
 “ under the microscope does not contain more than about a million organic
 “ molecules. Some exceedingly simple organism may be supposed built
 “ up of not more than a million similar molecules. It is impossible, how-
 “ ever, to conceive so small a number sufficient to form a being furnished
 “ with a whole system of specialised organs. Thus molecular science sets
 “ us face to face with physiological theories. It forbids the physiologist
 “ from imagining that structural details of infinitely small dimensions can
 “ furnish an explanation of the infinite variety which exists in the proper-
 “ ties and functions of the most minute organism.

“ A microscopic germ is, we know, capable of development into a highly
 “ organised animal. Another germ, equally microscopic, becomes, when
 “ developed, an animal of a totally different kind. Do all the differences,
 “ infinite in number, which distinguish the one animal from the other, arise
 “ each from some difference in the structure of the respective germs? Even
 “ if we admit this as possible, we shall be called upon by the advocates of
 “ Pangenesis to admit still greater marvels. For the microscopic germ,
 “ according to this theory, is no mere individual, but a representative body,
 “ containing members collected from every rank of the long-drawn ramifi-
 “ cation of the ancestral tree, the number of these members being amply
 “ sufficient not only to furnish the hereditary characteristics of every organ
 “ of the body, and every habit of the animal from birth to death, but also
 “ to afford a stock of latent gemmules to be passed on in an inactive state
 “ from germ to germ, till at last the ancestral peculiarity which it repre-
 “ sents is revived in some remote descendant.

"Some of the exponents of this theory of heredity have attempted to elude the difficulty of placing a whole world of wonders within a body so small and so devoid of visible structure as a germ, by using the phrase 'structureless germs. (See F. Galton, 'On Blood Relationship,' *Proc. Roy. Soc.*, June 18th, 1872.) Now, one material system can differ from another only in the configuration and motion which it has at a given instant. To explain differences of function and development of a germ without assuming differences of structure is, therefore, to admit that the properties of a germ are not those of a purely material system."

It is since that article was published in 1875 that most of the results laid before you in this paper have been reached, and I have often conjectured as to how far Professor Clerk Maxwell would have modified these opinions in the light of more recent research. Neither ovum nor spermatozoid is now to be regarded as destitute of structure, and the tendency of these researches is to show that the peculiarities of different ova depend on differences of molecular structure. Further, small as the reproductive body formed by the fusion of the male and female elements is, it is still large enough to contain *millions* of organic molecules having a complexity of structure as great as that of a molecule of albumen. The physiologist also lays stress on the fact that all the tendency of his work on these minute structures is in the direction of detecting *differences*, not necessarily physical in the sense of being discernible by any possible microscope, but differences of a chemical nature—in other words, molecular. Nor are the tissues so various, nor are individual peculiarities so numerous, as the physicist is apt to suppose. Much depends on vegetative repetition, so that, given the peculiarities of any individual, it is not improbable that a few thousand special types of cell formation, as regards molecular structure, would be sufficient to account for the special peculiarities. There is room enough for many such molecules in a cube of idioplasm having a side of 1-500th of an inch.

I have attempted to give a condensed account of the various theories put forward to explain the well-known facts of heredity in the light of present notions regarding cells, nuclei, and protoplasm. One feels in discussing such theories that not only are they still incapable of explaining all the facts, but that they are to a considerable extent re-statements of the facts we already possess. Nor can we think that the possession of hereditary characters by chromatin substance is less wonderful than the possession of these

properties by the ovum or by the spermatozoon. The ultimate problem is still mysterious, and it will continue to be so, even if it should be possible, at some far-off future in scientific research, to trace it to the play of molecular forces. A step has been made, however, and it is possible to frame a theory more consistent with fact than could have been done some years ago. An imperfect theory may be the guide to a better one, while in framing such theories, and in collecting facts from all possible sources, there is the intellectual satisfaction of endeavouring to reach the truth. The danger lies in adhering too closely to theory, and of substituting the theoretical explanation for the appreciation of the facts. Above all, the scientific spirit must beware of dogmatism. In the words of Sir Isaac Newton: "We are diffident in the presence of Nature."

V.—*Some early Treatises on Technological Chemistry.* By JOHN FERGUSON, M.A., Professor of Chemistry in the University of Glasgow.

[Read before the Society, January 6, 1886.]

§ 1.—During the sixteenth, seventeenth, and eighteenth centuries there was produced a considerable number of books dealing with the marvels of nature, with popular science and medicine, and with practical receipts for domestic and workshop use, which went under the common title of “secrets.” Elsewhere* I have enumerated some 300 of these, which have come under my notice from time to time, and have endeavoured to show that they are possessed of different degrees of merit, both as concerns their contents and themselves. Among them there are upwards of a score which, though published under different names, in different languages, and at different times, exhibit such close relationship to each other that they are obviously variations and extensions of one work. They are practically unknown to bibliographers and to the historians of chemistry, and there is nothing more than a hint existing as to their origin and authorship. Although I have mentioned most of them in the papers referred to, I have not exhausted what may be said about them, and I propose in the following to give a list of them in chronological order, and such descriptions as may exhibit their history and connection with one another. I have tried to make the list as complete as possible, but I do not doubt that there are editions of some of the forms of the collection which have escaped me. If it be so they must be even scarcer than those now described, all of which, the earlier editions especially, have been most difficult to procure for examination.

§ 2.—

1.—1531. Rechter Gebrauch d' | Alchimei, Mitt vil bissher verborgenen, nutzbaren vnnd | lustigen Künsten, Nit allein den fürwitzigen

* In my *Bibliographical Notes on Histories of Inventions and Books of Secrets*, communicated to the Archæological Society of Glasgow, and printed in their *Transactions* for 1883 and 1885. The present notes may be regarded as a supplement to these papers.

Alchimis- | misten (*sic*), Sonder allen kunstbaren Werckleutten, | in
vnd ausserhalb feurs. Auch sunst aller | menglichen inn vil wege
zuge- | brauchen. | ☞ Die Character, Figürliche bedeutungen, vnd
namen der Me | tall, Corpus vnd Spiritus. | ☞ Der Alchimistischen
verlateineten wörter ausslegung. | ☞ Register am folgenden blat. |

Small 4to, ff. xxvii, and one blank. Type of a somewhat florid kind is used for the title-page. Without place and printer's name. The date: M.D.XXXI. is on f. xxvii. verso. There is a vignette of a jeweller's shop on the title. On the reverse of the title are the symbols and names of the metals, &c., a list of certain Latin alchemical words, with their meanings, and the beginning of the table of contents, which ends on the reverse of f. ii. The text begins on f. iii., and runs on to f. xxvii. The first receipt is how to make imitation amber: *Agatsteyn zumachen artlich vnd klar*, and the last to refine gold: *Wie sich das golt gradirt*.

This is the earliest edition of the collection that I have seen, and I judge it to be the first, because I have found no reference to any one before it, and because it contains less matter than any of its successors. The book is not mentioned by any authority except Schmieder,* who says that it was written by George Agricola, the metallurgist, and that it was printed at Cologne; but there is no evidence in support of these statements in the book itself, and both of them are very questionable, if not demonstrably erroneous.

As to the place of printing.—Two years later, in 1533, Christian Egenolph, at Frankfurt-am-Main, printed a little tract of 39 leaves, entitled: *Bergwerck vnd Probirbüchlin*, including Gilbertus Cardinal on solution and parting of the metals, to be noticed below in connection with Kertzenmacher. On f. 32 of this tract there is the *identical* woodcut of a jeweller's shop—not a mere copy—which forms the vignette of the present treatise. Further, the *Bergwerck...büchlin* contains woodcuts of a muffle and furnace for assaying which were used over again in 1574, by the heirs of Christian Egenolph, for a book entitled *Probier Büchlein*. Now, in the preface to this latter work, and the head-line of each page, the same florid type is used as in the title-page of the 1531 edition. I have no hesitation in inferring from these coincidences that this first edition was printed by Egenolph at Frankfurt. Later editions (Nos. 7 and 11) were printed by Egenolph and his heirs, as well as an edition of Kertzenmacher, in 1574 (No. 12), which is uniform with the *Probier Büchlein* of the same year, above mentioned, and which contains the same florid type.

* *Geschichte der Alchemie*, Halle, 1832, p. 270.

As to Agricola's authorship.—Schmieder states that in his youth Agricola, who from his love of knowledge acquired the name of *Philopeustes*, had pursued alchemy and had written some treatises on it, which were sought for after he had distinguished himself in other ways; and then he gives the names of the said treatises, of which the *Rechter Gebrauch d'Alchimei* is one, and the other is entitled: *Galerazeya sive revelator secretorum*, I. *De lapide philosophico*,...printed, Schmieder says, in 1531 and 1534, dates already given by Dufresnoy (*Histoire de la Philosophie Hermétique*, Paris, 1742, III., p. 82), who has also assigned the *Galerazeya* to George Agricola. Schmieder's account seems to me to be purely imaginative. No one who has written about Agricola has mentioned these treatises, and they are not contained in the collected editions of his works; the *Rechter Gebrauch* was published long before Agricola's best-known works appeared, whereas the *Galerazeya*—at least the copy of it which I have seen—was printed at Cologne in 1631, not 1531. Further, the *Rechter Gebrauch*, as will appear from the abstract following, is a collection of practical receipts, whereas the *Galerazeya* has absolutely nothing to do with alchemy, but is a book of Roman Catholic controversy. The author was a certain *Daniel Agricola*, *Philopistius*, not *Philopeustes*, who lived to the comfortable age of 110 years, and whose whole life, as recorded in the introduction, does not tally at all with that of George Agricola the miner, metallurgist, and geologist. I have no doubt that Schmieder never saw a copy of the *Galerazeya*, but simply followed Dufresnoy. It is not so easy to understand what led him to credit Agricola with the *Rechter Gebrauch*. There is no indication of his being the author that I am aware of, and Schmieder has not noticed that a difficulty arises from the work of Kertzenmacher (which he himself has quoted [p. 280], and which I have included in the present series), having a similar title. Was Kertzenmacher the author of this first edition? In the meantime the author of it is unknown.

The contents of the book itself are entirely practical, and have little or nothing to do with speculative or transcendental alchemy. In this respect it is very remarkable that the author, whoever he was, should have affirmed, in the very title of his work, that the *right use of Alchemy* was not solely to transmute the metals, but to produce, by chemical art, different substances that were in constant demand for every day purposes, and to enable work-people and artists to compass their ends more easily and

successfully. The work is a collection of chemical receipts, which, doubtless, had been long and well known to alchemists, metallurgists, and others, but which may never have been reduced to a system. Anyhow, the existence of this and the later editions shows that, untrammelled by the unconfirmed theories of the alchemists, there was a desire to turn their incidental discoveries to some useful purpose. Apparently, anything that was worth, any process that would yield a definite result, was taken advantage of, and by degrees came to be widely known, and to form the common property of artists of different kinds, and to be placed in books of receipts and secrets.

A characteristic of this and the other books of the series is the absence of concealment under misleading names of the substances to be used and the processes to be followed. The alchemist was always at great pains to withhold the secrets of his art from those deemed ignorant and unworthy, and he was in the habit of expressing himself in an allegorical and enigmatical style, which is one of the chief obstacles to understanding what the alchemists would be at. In this book, however, there is nothing of the kind, and if there is obscurity occasionally, it is due less to the language employed than to the difficulty of identifying the bodies mentioned, or of seeing precisely what is the drift of the operation described.

This book exhibits very fairly the practical knowledge of chemistry at the beginning of the sixteenth century. Many of the processes seem very roundabout and even absurd now, but then they were the best to be had, and it must be remembered that three and a half centuries have elapsed from the date of the book which records them, centuries filled with research into the causes of the changes which at that time were only slightly known after the most tentative fashion.

The receipts are not arranged in any regular way, but for our present purpose it may suffice to consider very briefly the contents of the book under two main heads: A. substances, and B. processes.

A.—The substances which bulk most largely in the receipts are naturally the metals and some metallic compounds. Gold and silver, mercury, antimony, tin, lead, bismuth, copper, and iron are commonly spoken about. Brass was made from copper and calamine; amalgams of gold and silver were familiar, and the solvent power of mercury for these metals was employed for removing them from the others, as well as for getting calx of gold, that is to say, gold in a fine state of division. The parting of gold

from copper by antimony and by liquation with lead, the cementation and cupellation of gold, the separation of gold by aquafortis were all operations well-known at the time. Other operations were used for silver.

Gilding and silvering were largely practised, and the giving of a yellow and white appearance to other metals without the use of either gold or silver was often employed. But the method of distinguishing between true and imitation gold by streak and aquafortis is described also.

Mercury was much employed for the purposes above mentioned. Cinnabar was made from it artificially by heating it with sulphur; and sublimate is also referred to.

Copper was quite familiar. Besides being gilt, silvered, and tinned, it was converted into verdigris by acetic acid, from which a green colour was obtained; by the action of calamine it was made into brass; it was whitened by treatment with arsenic.

Lead was used in cupellation and liquation; it was converted into white lead by the action of acetic acid, and the process closely resembled that pursued at the present day; red lead was made by heating it in a furnace; and the so-called *lac virginis* was made by digesting litharge got in cupellation with acetic acid.

Tin was used chiefly for coating other metals and for alloying.

Bismuth is mentioned; a fusible alloy was employed for making casts; it was got by melting together lead, tin, and bismuth. This, therefore, is a very old alloy.

Of the compounds of iron, green vitriol and crocus martis are mentioned, as well as the red solution of ferric acetate.

Antimony is only mentioned in connection with the purification of gold.

White arsenic, orpiment, and realgar are referred to. Arsenic was used for whitening copper. It was fused with saltpetre, and the residue (consisting mainly of potassic arseniate) was called *fixed arsenic*. A solution called *aqua causata* was made by boiling together arsenic, realgar, calcined tartar, sal ammoniac, with a ley of ashes and quicklime.

Zinc itself is not alluded to, but *lapis calaminaris* or *galmey*, native carbonate of zinc, and white vitriol are mentioned.

Of the acids, the only two that are distinctly specified are acetic acid and nitric acid. The latter was made by heating together saltpetre, alum, and vitriol.

Though sulphur was much used, there is no reference either to

the acid spirit or acid oil of sulphur—that is to say, sulphurous or sulphuric acid. Two kinds of oil of sulphur are described, one made by distilling linseed oil with sulphur, the other by digesting sulphur with oil of tartar—that is to say, with a strong solution of carbonate of potash, but these are oils in a very different sense of the term.

The list of saline substances is comparatively limited. Besides those already quoted, it includes common salt, which was subjected to an elaborate but very imperfect purification; tartar, calcined tartar, ashes, sal alkali, caustic potash, both solid and in solution, made by boiling ashes with quicklime, which in its turn was got by calcining egg shells when wanted particularly pure; sal ammoniac, alum, and an artificial substitute for borax, consisting of carbonate of potash and common salt, or of tartar and common salt.

B.—The processes are of a very rudimentary character, and relate mainly to gilding, silvering, tinning, and calcining the different metals, under which term was included, in pure ignorance of the different results, a good deal more than would be understood now, purification and refining of the metals and alteration of their appearance and properties, the separation or parting of the metals, the rendering of them more malleable, the formation of various solutions or waters as they were called, the preparation and purification of the salts and compounds previously mentioned. There are besides some miscellaneous receipts. The very first receipt in the book is to make imitation amber. This was done by boiling turpentine and oil together till thick, stirring well, and pouring into a mould and exposing to the sun for eight days. Out of this could be cut Paternoster beads, knife handles, &c. Another method was to make a mixture of egg yolks, gum arabic, and cherry gum, and allow it to harden in the sun. It became transparent, and “when rubbed, it attracted straws like other amber.” According to another, gems were polished with powdered antimony (that is to say, the native sulphide) on a leaden sheet. A pyrophorus was made by heating a loadstone with sulphur very slowly up to incandescence, keeping it in that state for three days and nights, and then allowing it to cool. When moistened it burns. Imitation pearls were made from mussel and snail shells, thoroughly clean, powdered in a mortar, washed on a cloth in the sun, dried, and calcined. The residue powdered, was added to pure white of egg and thoroughly stirred in, and then moulded “with carefully

washed hands" to the required size, a hole drilled through the pearls while still soft, which were afterwards dried in the sun. They were finally polished in red wine, and fair pearls were thus got. Scented pastilles were made with labdanum, storax, cinnamon, and other odoriferous substances mixed with charcoal powder, the whole converted into a paste with gum tragacanth and water, which was then moulded into pastilles with the hand. *Petroleum* was obtained by soaking bricks or tiles in oil and then distilling at a high temperature. These operations involved furnaces and vessels which are mentioned as things sufficiently well-known, and the operations themselves consisted in digesting with acetic acid and other menstua, in crystallization, precipitation, sublimation, cupellation, cementation, roasting, fusion.

In no case is there any explanation of a process given—in no case does there appear to have been even a rudimentary conception of the rationale of it. On the contrary, the results were sometimes entirely misunderstood, substances or products were misnamed, and there was no notion of the permanence of the matter operated on, or of the constancy involved in the various changes. There is, for example, a process for "hardening mercury" which, assuming that the substances employed were the same as those denoted by the names now, and so far as the operations are intelligible, could not lead to the result supposed. A small hollow or depression is made in melted lead before it solidifies. Over this a cloth is placed, and then mercury on the cloth, and the whole is set in warm ashes till the "mercury" becomes hard. The "hardened mercury" is broken into pieces and placed in strong "vinegar," or in juice of the plant ox-tongue, vinegar, and oil, and boiled for a quarter of an hour. The "mercury" is mixed with sal ammoniac and vinegar in a luted vessel and left for eight or ten days; the "vinegar extracts all the roughness from the mercury;" the "mercury" is transferred to another vessel in a wind furnace, where it is heated gradually to redness till it detonates. The "mercury" is then hung in a pot with sulphur at the bottom of it, and a gentle heat is applied to vaporise the sulphur. This is to be repeated once a day for thirty days. The "mercury" is now removed, and can be hammered and fused. This "mercury," melted with twice its weight of copper, gives a product which behaves to all tests like genuine silver.

So far as one can see, the sole result of this curious operation, lasting five or six weeks, is to yield the lead that was begun with,

or sulphide of lead, while a quantity of mercury is sent up the chimney of the wind furnace.

Time and reiteration were important factors with the early chemists. Here is another example: "To make gold from mercury." A parting water (nitric acid) was made out of vitriol (sulphate of iron), saltpetre, and plumose alum, into which crude mercury was put. The "water" was distilled off and poured back again, or new "water" was added, and the whole was put in a long-necked flask to which a little alembic was well luted, with a receiver, and the water distilled away from the mercury by means of a gentle fire till the mercury became red like blood, and gave no fume when heated, "which will happen in three months" (!!). "Test it for two or three months, the mercury will become fixed, reduce it quickly with borax or saltpetre and it will be changed into true gold."

Here, again, there is a consumption of three whole months, an endless amount of labour and expenditure of material to make what appears to be nothing more than red oxide of mercury. As for the transformation into true gold, that may have been due to the mercury containing some gold when used for the operation described, or it may not have been gold at all. It is almost useless to try to determine what the authors of these methods exactly intended, or whether the substances are the same as ours, or whether they were pure or not, or, in short, anything about the details. All the processes are quite empirical, and as the chemical properties of the substances employed were virtually unknown, they must have often neutralised each other's effects instead of contributing to the wished-for result. That, however, was inevitable in the then state of science; rather we may wonder that so much was known as seems to have been the case.

This collection forms the groundwork of the edition of 1537, and is contained in whole or in part in almost every one of the editions.

- 2.—1532. Kunstbüchlein. Allerley Mackel vnd Flecken aus gewand, Sammt (*sic*), Seiden, etc. zu bringen. Dazu auch wie einem jeglich Gewand seyn verlorne farb wider zu bringen sey, desgl. Garn und Leinwand zu farben etc. Nürnberg. d. Cunigund Hergotin 1532. in-4°. (¾ th. Lempertz.)

This book is quoted by Graesse (*Trésor de Livres Rares*, Dresden, 1863, t. iv., p. 53), but I have not seen it. To judge from the title, it is quite different from No. 1; but it would be

interesting to know if it is the first, or an early edition of the tract with the same title, on the same topic, which is included, along with No. 1, in the 1537 and others of the later editions. That could only be settled by actual comparison of the contents.

It may be mentioned here that Graesse quotes other two tracts entitled *Kunstbüchlin*. One was printed at Erfort in 1599, the other, compiled by Heinr. Vogtherr, appeared at Strassburg in 1538. These tracts seem to be quite distinct from the series now under consideration. I have not seen them.

3.—1537. *Kunstbüchlin, gerecht- | ten gründtlichen gebrauchs | aller kunstbaren Werckleüt. |*

Von { Ertzarbeit, inn vnd ausserhalb feurs, auss Alchimistischem |
vnd natijrlichem grund, nemlich,
Härten, Weychen.
Schmeltzen, Schaiden.
Abtreyben, Probiern.
Löten Etzen.
Abformen, Abgiessen &c.
Jede farben zubereiten, erhalten,
beasern vnd widerbringen, als zum
Malen, Schreyben.
Illuminieren, Vergulden.
Sticken, Edelgestain &c.
Alles Jnhalt zu end beygelegten Registerlins.

M.D.XXXVII.

Small 4to, ff. xxxvii., and 1 of index. The vignette contains pictures of the instruments employed in the processes.

Colophon: Getruckt zu Augspurg, durch Heinrich Steyner, | am XVIII. tag Junij, im̃ N.D.XXXVII. (*sic*) Jarr.

This book may be divided into two parts. Leaves 16 verso to 37 contain a simple reprint of the whole contents of the edition of 1531, No. 1, about which, therefore, there is nothing more to say. The preceding leaves, however, contain additional receipts, of which the following is a brief abstract:—

Leaves 2-6 are occupied with receipts for working with iron and steel. These metals were tempered by heating with horn shavings, or blood, or leather, the colour of the steel was noted, and degrees of temper were given to different tools by quenching in water, in infusions of plants, in tallow, in oil, in soap, and other substances.

The so-called solders were fusible mixtures of various kinds. One employed for joining iron in the cold was made up of sal ammoniac, common salt, calcined tartar, bell-metal, antimony,

all ground intimately together, and made into a paste with glue. This was heated very slowly to fusion, then, when cold, it was reduced to fine powder. The two pieces of iron, fitting as closely as possible, were fastened to a board, with paper below, the powder was laid on, and moistened with wine, in which *borras* (I presume the artificial mixture already referred to under No. 1) was dissolved; after the ensuing ebullition was over the action was complete, and the superfluous material was rubbed off. Supposing there was an action, it is not easy to see what part the different ingredients took in it. For copper, a solder was made of copper and white arsenic, and brass filings were also used.

Fluxes for ores were made of sandever, ashes, lime, pounded salt, tartar, and saltpetre, all powdered together and thrown upon the ore. Another contained sulphur, lead, litharge, saltpetre, salt, sandever, all well powdered and mixed. These mixtures would undoubtedly slag or vitrify when heated.

Etching upon iron and steel was carried out by coating the surface of the object with wax, or with massicot or red lead and oil, cutting the pattern through the film, and then acting on the metal thus exposed with a water containing verdigris, mercury sublimate, vitriol, and alum, or laying on mercury sublimate and moistening with strong vinegar. This seems to have been one of the ways for ornamenting armour.

Metal objects received a gold colour by being covered with yellow varnish. Copper was silvered by grinding intimately on a slab tartar, alum, salt, and silver leaf, adding water and dipping the copper in it, and then brushing with a scratch brush. Iron or steel was prepared for gilding by depositing copper on it from a mixture of verdigris and sal ammoniac.

Leaves 6-7 contain the receipts for taking spots and stains out of cloth. The title of this section corresponds exactly with that of the preceding work, No. 2; and I have little doubt that a portion, if not the whole, of that tract is incorporated in the edition of 1537.

The detergent employed was chiefly wood ashes causticized with slaked lime, and in this the stains were steeped and the fabric afterwards thoroughly rinsed with water and hung up in the air to dry. The operator is warned to keep coloured fabrics out of the sun, lest the colours fade; and among the receipts under this division is one for stiffening silk with gum.

The receipts about ink occupy leaves 8-10. The materials used

were nut galls, green vitriol, and gum water; but they were applied in a variety of ways, and, singularly enough, the importance of using proper proportions was insisted on as a preliminary instruction.

Invisible ink was procured by writing with vitriol and then washing with infusion of nut galls. Another plan was to write with white of an egg, wash ink over the whole surface, and then scrape with a knife where the writing was to be read.

Writing was obliterated by washing it with the distillate from a mixture of sal ammoniac and alum.

Leaves 10-16 contain the sections upon colours and their use. The colours were partly vegetable, partly mineral. Thus, a red colour, a lake, was got from Brazil wood, alum, and lime water, gum being added. A bronze colour was made from the same wood with *galitzenstein*, which is native white vitriol. Yellow was made from saffron, and from the yolk of eggs. Green was obtained from buckthorn and alum; verdigris was used, and also a mixture of indigo and orpiment. What was called Greek green was merely verdigris. Blue colours were got from plants—the juice of elder berries with alum and lime water, of bilberries, of mulberries, and of corn flowers. A mixture of white lead and indigo was also used. The preparation of mosaic gold is given in tolerable detail; the materials employed were sal ammoniac, mercury, conterfey (a fine coloured brass), and sulphur. Another mixture was tin, bismuth, mercury, sal ammoniac, and sulphur. Mosaic silver was merely tin amalgam. An extraordinary method of getting a gold colour was to blow an egg, fill it with mercury rubbed up with egg-yolk, lute the holes and put the egg, along with half-a-dozen others, to be hatched!! At the end of three weeks the colour is ready.

Gold leaf was used. The metal was ground with honey and salt, and put in a shell, then it was applied with gum water and burnished with a tooth.

Another way of applying metals was to write with finely powdered crystal or pumice and gum water, then rub on the metal till there was enough, and finally burnish. Several receipts of a similar kind are given.

The next section refers to the dyeing of horn, feathers, bone, parchment, and the methods were the same for all. Feathers, for example, were steeped in alum and then put into the colouring material. Yarn and cloth were dyed in the same way. Thus, to

dye a red, the cloth was limed and then steeped in Brazil-wood and alum; cinnabar also was used and lees of red wine, but no distinction is drawn between mordant and pigment colours.

The preceding, without exhausting the variations in the receipts, will give some notion of the substances employed and the processes pursued. Certain practical results were undoubtedly attained, but at a great expenditure of time and of material, and with an uncertainty inherent in every empirical process, in which what is essential and what non-essential to success are unavoidably confused. These receipts, however, were plainly considered of the very best and most authentic kind, and they are therefore well worth notice and consideration.

- 4.—1538. Kunstbüchlein gerechten gründlichen Gebrauchs aller kunstbaren Werken. Von Ertzarbeyt etc. Härten, Weychen, Löten, Etzen, Abformen, Malen, Schreyben, Luminiren, Sticken etc. Augsp., H. Steyner 1538. in-4°. (38 ff.) Av. fig. en bois. (22 gr. Lempertz.)

This is a second edition of the previous work, No. 3, 1537. The title is taken from Graesse, *Trésor de Livres Rares*, Dresden, 1863, t. iv., p. 53. See also No. 7, 1550. Graesse does not mention the previous edition.

- 5.—1539. Alchimia. Wie man alle farben, wasser, olea, salia vnd alumina, damit man alle corpora, spiritus vnd calces preparirt, sublimirt vnd fixirt, machen sol. Vnd wie mann dise ding nutze, auff das Sol vnd Luna werden mög. Auch vom soluiren vnuud schaidung aller metal, Polirung aller handt edel gestain, fürtrefflichen wassern zum etzen etc. ein kurtzer begrif. Strassb. Cammerlander, 1539. kl. 4. Mit Holzschn. Hlbldr.

This title is taken from the *Antiquarischer Katalog* of C. H. Beck, Nördlingen, No. 165, 1885. The book itself I have not seen, but to judge from the title it is an early edition, perhaps the first, of the work that bears the name of Petrus Kertzenmacher. See No. 9, 1570; No. 12, 1574; No. 16, 1589; No. 21, 1613; No. 26, 1720, and No. 29.

- 6.—1549. \square Kunst Boeck. | Nyeulijck | wten Alchemistischen | gront vergadert, Tracterende | van allen grontlijkē gebruyc- | kinghen der cunsten. Nutlijck | voor allē wercluidē, als Munt | meesterē, Goltwerckerē, schey | deren, Goltsmeden, schilderen | eñ alle ander wercluydē, werc- | kende in stael, Yser, coeper, eñ | alle andere metalen. | \square Ghecolligeert eñ eensdeels | getraslateert, door Symonem | Andree van Aemstelredam. | \square Niemāt is hatende de cunst | dan die onwetenen. | 1549 |

16mo. Title, surrounded by a woodcut border with flowers, fruit, musical instruments, male and female *termini*, &c.; on the reverse is a

picture of a chemist in his laboratory. Besides the title-leaf, there are liij numbered leaves, and 5 leaves of contents.

The last leaf contains the device of the publisher : a hooded falcon perched on the branch of a withered tree, with the monogram Ck in the corner, and mottoes on three sides.

The colophon is on the reverse of Hiiij :

Geprent toe Campē, in die Broeder | straet by mi Steuen Joessen.
Anno. M.D.LI. | ~~en~~ Voor Cornelis Karelsen, Woenende tot | Aemstel-
redam by sinte Olifs poorte int guldē | Missael. Voorstaēde op die
Nieuwebrugge | aent Paelhuysken. |

This is a translation into Dutch, with some modifications, of the German edition of 1537. It is divided into six tracts, and this is the first notable difference between the two, though the succession of the receipts is in reality the same. Another important difference is the omission in this edition of the sections referring to inks and colours (Ed. 1537, ff. 8-14), and of certain of the receipts for the tempering of iron, while some new ones have been added. The contents of the tracts are as follow :—

Tract I. treats of “iron, steel, and other materials, and how to harden, soften, and solder them, of etching on the same, of colouring, gilding, and silvering.” It begins: *Om yser hart te maken*, and it corresponds to ff. 2-6 in the 1537 edition, a few of the receipts being omitted, and one or two new ones added.

Tract II. contains receipts for “removing, by means of water or lye, stains or spots from cloth, velvet, silk, or other stuffs, whether of oil, fat, wine, or whatever it be, and that easily and without injury.” This includes ff. 6-7 of the 1537 edition, but a few receipts of the same character are added in the Dutch version. The first receipt is how to restore the colour to cloth: *Om laken sine verloren verwe weder te gheuen*.

Tract III. deals with the “colouring of wool and linen, the making of the colours, the colouring of horn and bone, the softening and moulding of horn.” The first receipt is to dye yarn or linen brown: *Om garen oft lijnwaet bruyn te verwen*; then follow more colour receipts, and those on bone and horn which occupy ff. 15-16 in the 1537 edition. This completes—as above-mentioned—the first section of the 1537 edition, which is succeeded by the reprint of that of 1531. The same thing occurs in the Dutch version, for towards the end of this third tract is found the receipt for “making a clear, fair amber,” *Agatsteen aerdich ende claer te maken*, as it is given in the 1531 edition (f. 3). This third tract contains at the end a few receipts, which do not occur in the

German versions, as to dye silk black, which was effected by boiling it for an hour in galls, and then putting it in a black colour made from gall-nuts and copperas, with rye meal, old iron, hammer scales; to dye silk and hoofs red by boiling in alum water, and then with madder; to dye yarn black by boiling pounded galls in water, taking the galls out and adding Roman copperas and a little gum arabic, and then dipping the yarn in the pot. The same mixture diluted with water was used for grey.

Tract IV. "teaches the gilding, silvering, and colouring of copper, iron, &c., how to fuse and cast them and make certain colours." This, which begins with the hardening of mercury, so that it may be hammered, cast, and worked, *Om Mercurium te arbeiden ende harden datmense smeen, gieten ende arbeiden mach*, corresponds with ff. 4-8 in the 1531, and with ff. 17-20 in the 1537 editions. One or two receipts are again added, such as to mend broken glass by a cement of red lead, quicklime, fine dust from a forge, white of egg, laid on with a cloth; to make *lutum sapientiae*, a mixture of lime, horse-dung, iron filings, clay, white of egg, and salt water or ox blood. This was used for vessels which had to be heated to a high temperature, or for luting up subliming pots, and for similar purposes.

Tract V. relates "to the parting of gold, silver, copper, &c., and to testing them; useful and profitable for all goldsmiths, merchants, and others concerned therewith," and commences with the separation of gold and silver: *Om Golt te scheyden wt Syluer*, which is done by treating the conjoined metals with aquafortis at a gentle heat as long as bubbles escape. The fluid is poured into a copper dish on which the silver deposits. The gold which remains in the glass is collected and fused. A considerable variety of methods is given, and there are receipts for colouring metals so as to make them look like gold and silver. There is greater divergence from the earlier German editions in this tract than in any of the others, alike in the way of addition, omission, and alteration of the order in which the receipts come.

Tract VI. repeats the title of the book, as it is concerned "with certain actions of Alchemistic things, to make gold and silver, and also with all calcinations of the planets [i.e., the metals], to make waters and oils of the same, wherewith to produce wonderful effects." It begins with the making of gold from mercury, and follows almost exactly the order as given in the German editions. This tract is therefore a strict translation

of ff. 13-27 of the 1531, and of ff. 25-37 of the 1537 editions, with transpositions of certain receipts.

Of Andree, or Andriessen, as he is called in the later editions (Nos. 14, 19), I have failed to find any particulars. He has fulfilled his promise, for his miniature collection is mainly a selected translation from the German, which he has supplemented from other sources, or from his own experience. It may be observed, however, that in the receipts which he has translated he has introduced no modification or improvement. Such a thing, if thought of, was either kept as a special secret, or else it was given as a separate receipt or method.

7.—[1550 ?]. Kunstbüchlin, gerecht- | ten gründtlichen gebrauchs aller | kunstbaren Werckleut. |

Von { Ertzarbeyt, in vñ ausserhalb feurs, auss Alchimistischem |
vnd natürlichen grund: nemlich,
Härten, Weychen.
Schmelzen, Scheyden.
Abtreiben, Probirn.
Löten, Etzen.
Abformen, Abgiessen &c.
Jede farben zubereyten, erhalten,
bessern vnd widerbringen: als zum
Malen, Schreiben.
Illuminiren, Vergulden.
Sticken, Edelgesteyn &c.

¶ Alles Inhalt zu end beigelegten Registerlins.

¶ Zu Franckfurt am Meyn, bei Christian Egenolph.

Small 4to, ff. 37, and contents [1]. The vignette on the title is the same as that in the edition of 1537. There is no date or colophon.

This book is a word-for-word reissue of the edition of 1537, No. 3, but it is not nearly so nicely printed. I presume this is the edition referred to by Graesse, who, in a note to the *Kunstbüchlein*, 1538 (No. 4 above), says: "Il y en a une seconde éd. Frckft. a. M., Chr. Egenolff (vers 1550). in-4°. (1 th. R. Weigel)." Graesse, so far as I know, is the only writer who alludes to an undated edition of the book.

8.—1563. Ettliche Künste, | auff mancherley weisz Din- | ten vnd aller-
hand Farben zu bereyten. Auch | Gold vnd Sylber, sampt allen
Metallen ausz der | Feder zu schreiben, Mit vil andern nützlichen
künst | lein. Schreibfedern vnd Pergament mit al- | lerley farben zu
ferben. Auch wie man | Schrift vnd gemälde auf Stä- | helene,
Eisene waaffen vñ | dergleichen, etzen sol. | Etliche zugesetzte Kün-
stücklin, vormalis | im druck nie ausgangen. | Allen Schreibern,

Brieffmalern, sampt | andern solcher Künsten Liebhabern, gantz |
lustig vnd fruchtbar zu wissen. | Den Inhalt dises Büchlins, vnd
was | für künst hierinn begriffen, findest du | anderseits dises Blats. |

Getruckt zu Straszburg bey | Christian

Müller, Im Iar | M. D. LXIII. |

Small 8vo, signatures A—C, or ff. 24, not numbered.

This small volume consists of a reprint from the edition of 1537, No. 3, of the sections on inks, colours, etching, and cleaning of silk and other fabrics. To these are added one or two additional methods of making a red colour with Brazil wood, and methods of colouring horn, bone, glass, and a pretty full section on the dyeing of leather.

9.—1570. Alchimia, | Das ist, | Alle Far- | ben, Wasser, O- | lea, Salia,
vnd | Alvimina, damit mann alle Cor- | pora, Spiritvs vnnd Cal- | ces
Prepariert, Sublimiert vnnd Fi- | xiert, zubereyten. Vnd wie mann
di- | se ding nütze, auff dasz Sol | vnd Lvnna werden | möge. Auch
von Soluieren vnnd schey- | dung aller Metall, Polierung allerhandt |
Edelgestein, fürtrefflichen Wassern zum Etzen, | scheyden vnnd
Soluieren. Vnd zuletzt wie die | giftige Dämpff zuuerhüten, ein
kur- | tzer bericht, &c. | Cum Gratia & Priuilegio Imperiali. | Zu
Franckfort am Meyn. | M. D. LXX. |

Small 8vo, ff. 79 (misprinted 77), and a leaf of Contents. There are 9 pages occupied with woodcuts of different kinds of furnaces and distilling apparatus. In the text is a cut (repeated three times) of a man engaged in tending a furnace with a still, and one of a flask (repeated four times). The title is printed in red and black, and on the reverse is a list of Latin chemical words, with their meanings, copied from the 1531 edition.

Colophon :—Zu Franckfort am Meyn, Bey | Christian Egenolffs Erben. |

In this edition the word “Alchimia” is in black and the initial A of “Alle” is in red. This arrangement is reversed in the editions of 1574, 1589, 1613, but is resumed in that of 1720.

This edition is the only one mentioned by the Author of the *Beytrag zur Geschichte der höhern Chemie*, Leipzig, 1785, p. 577; by Gmelin, *Geschichte der Chemie*, Göttingen, 1797, I., p. 293; and by Schmieder, *Geschichte der Alchemie*, Halle, 1832, p. 280. Gmelin and Schmieder, however, have simply quoted the *Beytrag*.

Though I have been unable to compare them, I have no doubt that this is an edition of the book with the same title published in 1539, No. 5. No author's name is given, but there is a preface by a certain “Petrus Kertzenmacher, sometime burgher at Maintz, a renowned alchemist.” Who Kertzenmacher was does not appear; Schmieder says that he is unknown. I have met

with no notice of him, and the name may be fictitious. In his preface he says that all art is from God, who imparts it to those who desire it of him. Men desire what is most of use to them; they therefore seek out strange crafts, but only for their own advantage, not for God's glory, and thus they but seldom succeed. Among the arts, "Alchimia" is the best and highest, for whoever has it overcomes everything. But it is very obscure, for the old masters of the art would not teach it to their children and friends. Happy, therefore, is he who finds it, for it is not soon found. Labour, however, conquers all things, and if one seeks right arts with diligence and earnestness it will not be in vain. In this art of Alchimia one must know the materials (which Kertzenmacher undertakes to describe), such as cinnabar, ultramarine, verdigris, white lead, green vitriol, alum, white vitriol, tartar, zinc white, calamine, orpiment, arsenicum, sulphur, sal ammoniac, saltpetre, sal alkali, sal preparatum, sal borax, and the seven metals—gold, silver, mercury, iron, tin, lead, and copper. He next points out that certain of the substances are called *bodies*, such as gold and silver, which are fixed when heated; while others are called *spirits*, such as sulphur, mercury, sal ammoniac, and arsenicum, which cannot abide the fire, but fly away. Whoever will have a true knowledge of the art must be able to make the spirits become bodies, so as to remain permanent in the fire. How this is to be done Kertzenmacher promises to teach, and he accordingly divides his treatise into two books, the first descriptive of the materials, the second of their use in transmutation.

To judge from the preface, Kertzenmacher claims—at all events he does not disclaim—the authorship of the work; but when we come to the first book we find it introduced by the following title:—

Rechter gebrauch der Alchimei, mit viel biszher verborgen, nutzba-
ren und lustigen Künsten, nit allein den Alchimisten, sonder allen Kunst-
baren Werckleuten, auch sonst aller meniglich inn viel wege zuge-
brauchen—

which is to all intents identical with that of 1531. Like the title, a considerable portion of the first book is taken from the 1531 edition, but there are some transpositions and variations and a few additions, such as the description of furnaces; while the receipts in the first edition, which were considered as not bearing upon transmutation, have been omitted. Kertzenmacher's work is therefore only a selection from the main series, but as

such I have considered it necessary to include it in the present list, especially as the compiler has seen fit to appropriate the original title. The receipts in this book relate to the substances above enumerated, and include the calcination of the metals, the preparation and purification of some salts, and the making of certain solutions or waters, which have been already alluded to under the first edition, 1531.

The second book deals with what was called transmutation, in reality the formation of white and yellow alloys and amalgams, or, in certain cases, of mixtures containing gold or silver. The few receipts on this subject which are to be found on ff. 17-19 of the 1531 edition are included, but the greater part of the book is either altogether new, or is taken from some other work with which I am unacquainted. The receipts are purely empirical, and much labour and time were spent in repeating over and over again such operations as solution, crystallization, sublimation, with the view of getting the materials into the proper state for the required action. As these operations were performed without any principle, the results expected were never attained at all, or, if they were, the same results could be got at now with vastly greater rapidity and sureness. In the sixteenth century, however, the knowledge was non-existent, and the experimenter could work only according to his lights, as has to be done at the present day.

The concluding operation of this book is the separation of gold and silver. *Aqua fortis* is poured into a glass with a long neck, which is set in ashes over a furnace and heated by a gentle fire. The alloy in small pieces is thrown into the flask, a condenser is adapted to it, and the whole is distilled to dryness. After the flask is cold the gold is found at the bottom, the silver adhering to the flask like crystal. On breaking the glass the two products are kept apart; each is melted with a little borax, and in this way good gold and silver are separated from one another. If all the receipts were as clearly described as this there would be little room for criticism, and considerable cause for surprise and admiration. (Compare No. 6, 1549, Tract V.)

Appended to Kertzenmacher's treatise is a reprint of the tract on the solution and parting of metals by Gilbertus Cardinal; on the polishing of precious stones; on excellent waters for etching, parting, and dissolving; on precautions to be taken against the poisonous vapours of metals. These tracts, so far as I know, first appeared along with the *Bergwerck vnd Probir büchlin*, printed by

Christian Egenolph at Franckfurt in 1533, in square 8vo, of 39 leaves. They are included in all the editions of Kertzenmacher's work subsequently quoted (No. 12, 1574; No. 16, 1589; No. 21, 1613; No. 26, 1720), but they do not form part of the present series of receipt books. The *Bergwerck vnd Probir büchlin*, however, is of special importance, as affording part of the proof that the same Egenolph was the printer of the *Rechter Gebrauch d'Alchimei*, 1531. See No. 1.

- 10.—1573. In the British Museum there is an edition of the *Secrets of Alexis*, in French, printed at Paris, in this year, by Hierosme de Marnef and Guillaume Cauellat, in a fat little 16mo of 911 pages, besides a long index of 80 pages. It was edited by Dr. Christoffe Landré, who added to the original work of Alexis collections of secrets from other sources. One of these was the *Kunstboeck* of Andriessen, of which a translation in full is contained in pp. 760-846. Like it, the translation is divided into six tracts, which follow in the same order as in the Dutch.

The first tract treats of metals, and begins: *Pour endurcir le fer.*

The second: *Pour rendre à un drap sa couleur perduë.*

The third: *Pour teindre filet ou toile en brun.*

The fourth: *Pour preparer le Mercure.*

The fifth: *Pour separer l'or de l'argent.*

The sixth: *Pour faire or de Mercure*, and it ends: *Pour gradir l'or.*

In this French version there are a few minor differences; but Landré simply incorporated the whole contents of the 1549 edition in his collection of receipts. From the division of the translation into six sections, it must have been made either from the Dutch, or from some other similarly-arranged edition which I have not seen, and not from the German of 1537, which, as has been already pointed out, runs on without any formal sectional arrangement.

The remainder of Landré's work has nothing to do with the present series of receipt-books. For later reprints, see No. 13, 1576; No. 23, 1637; and No. 25, 1691.

- 11.—1574. *Kunstbüchlin*, | Gründtlichen | rechten gebrauches, | aller
Kunstbaren Werckleut. Von | Ertzarbeyt, in vnd ausserhalb Feuers,
auss | Alchimistischem vñ natürlichem grunde, Nemlich: | Härten,
Weychen, Schmeltzen, Scheiden, Abtrei- | ben, Probirn, Löten,
Etzen, Abformen, Abgiessen, &c. | Jede Farben zubereyten, erhalten,
bessern, vñnd wi- | derbringen: Als zum Malen, Schreiben, Illu- |
miniren, Vergulden, Sticken, | Edelgesteyn, &c. |

Alles Jnnhalt zu endt beygelegten Registers. |

Mit Röm. Key. Maie. Priuilegien. |

1574 |

Franckfort, Bey Chri. Ege. Erben. |

Small 8vo, ff. 84, and Innhalt, ff. [3]. Title red and black. The vignette is a man cutting discs on an anvil with hammer and punch.

Colophon :—

Getruckt zu Franckfort | am Mayn, bey Christian Ege- | nolffs Erben,
In verlegung D. Ada- | mi Loniceri, M. Johannis Cnippij, vnd | Pauli
Steinmeyers, Jm jar | nach der Geburt Christi | vnsers Erlösers, |
M. D. LXXIIII.

The title is from a copy in the British Museum [1033, c. 12 (3)]. This is a reprint of the 1537 edition, No. 3.

- 12.—1574. Alchimia, | Das ist, | Alle Far- | ben, Wasser, O- | lea, Salia,
vnnnd | Alvmia, damit man alle Cor- | pora, Spiritvs vnnnd Cal- | ces
Prepariert, Sublimiert vnnnd Fi- | xiert, zubereyten. Vnnnd wie man
di- | se ding nutze, auff das Sol | vnnnd Lvnna werden | möge. | Auch
von Soluieren vnnnd schey- | dung aller Metall, Polierung allerhandt |
Edelgestein, fürtrefflichen Wassern zum Etzen, | scheyden vnnnd
Soluieren. Vnnnd zuletzt wie die | giftige Dämpff zuuerhüten, ein
kur- | tzer bericht, &c. |

Cum Gratia & Priuilegio Imperiali. !

Getruckt zu Franckfort am Mayn, |

M. D. LXXIIII.

Small 8vo, ff. 79, and Register f. [1]. Title red and black. Woodcuts of stills and furnaces.

Colophon :—

Getruckt zu Franckfurt | am Mayn, bey Christian Ege- | nolffs Erben,
In verlegung D. Adami | Loniceri, M. Johannis Cnippij, vnd Pauli |
Steinmeyers, Jm jar nach der | Geburt Christi vnsers | Erlösers, |

M. D. LXXIIII.

The copy of this in the British Museum wants ff. 9-24 ; that in my own possession is perfect. It is a simple reprint of No. 9, 1570.

A third volume, uniform with this and the preceding, published in the same year, and with the same colophon, is the *Probier Büchlein auff Goldt, Silber, Ertz vnnnd Methal, mit vil köstlichen Alchimistischen Künsten*. This is the reprint of a treatise with an almost identical title, which appeared without place, date, or printer's name several years earlier. Though this 1574 reprint does not form one of the present series of books, it also is of importance, as furnishing evidence that the first edition of all, that of 1531, was printed by Egenolph. See No. 1.

- 13.—1576. Les Secrets Dy Seignevr Alexis Piemontois, Divisez En Devx Parties, . . . Avec La Troisieme Partie Des receptes de diuers autheurs, toutes bien experimentées & aprouuées : . . . Par Christofle Landré, . . .

A Paris, De l'Imprimerie de Hierosme de Marnet, & Guillaume Cauellat, . . . 1576.

32mo, pp. 911 ; Table, signatures MMM—QQQ viii (?)

This is a reprint of No. 10, 1573, and, as in it, pp. 760—846 of Part III. contain the translation of Andriessen's *Kunstboek*. The translation is divided into the six tracts, arranged in the same order as in the earlier edition and in the Dutch.

14.—1581. Een schoon Trac | taet van sommige werckin- | gen der Alchemistische dinghen, om | Gout, siluer te maken, ende oock van alle calcione- | ringhe der Planeten, ende andere Materien | waeteren ende olyen der seluer te maeken, | om wonderlicken daer mede te wercken. | Noeh een Schoon Tractaet | Boecxken, Inholdende van alderley | verwen te maecken, ende ooc hoemen alderleye Ver- | wen wrijuen ende legghen sal, Ende is seer goedt | ende profijteliicken, voor allen Schrijuers Schil- | ders, Conterfeyters, en andere Stoffier- | ders, Oock allen anderen Liefheb- | bers der Consten. Inholdende. | xxxiiij. Capitelen. | Ghecopuleert ende toesaen ghe- | bracht dorch Symon Andriessen, | van Aemstelredam |

Gedruckt toe Reess, By my Derick | Wijlicx van Santen. Anno. 1581. |

Small 8vo, ff. xxviiij, numbered ; Tafel, 2 leaves not numbered ; "Een schoon Tractaet van de Alchemistry" 2 leaves, not numbered, at the end of which is the Colophon: Gedruckt toe Reess, By my Derick | Wylicks van Santen. | Anno. 1581. | It is printed in black letter.

This little volume contains two tracts. The first, beginning: "Eerst Goudt wt Mercurio te maecken," and ending: "Hoemen dat Goudt gradiert," corresponds with the sixth and last tract in the edition of 1549, No. 6, and therefore with the last half of the edition of 1531, No. 1, or with leaves 25-37 of the 1537 edition, No. 3. The second tract consists of a series of receipts, dealing chiefly with the preparation of colours for the use of "scribes, painters, copyists, decorators, and other lovers of the arts." Though it contains two or three of the receipts on colours which appear in the 1537 edition, No. 3, and in the third tract of that of 1549, No. 6, the order is different, and there are both omissions and large additions. The origin of these receipts I do not know ; they appear for the first time in this edition as forming part of this series of books. They are distinguished from the bulk of the other receipts by the very minutely detailed descriptions and by the precise nature of the preparations, and the directions given show what trouble the old artists took to have their substances in the best possible state. The first receipt is how to make

varnish for scribes. Egg shells, thoroughly clean and dry, were reduced to an impalpable powder by pounding and sifting, and then mixed most intimately with the finest white or yellow frankincense. This, when required, was dusted from a box with small holes, till the material got a smooth surface. Another mixture was oyster shells and rosin intimately mingled. This was cheaper, but it had the disadvantage of being brown. Scribes' chalk was made by pounding the best white dry chalk as fine as possible. White of egg whipt and filtered was mixed with milk, and this in successive portions was added to the chalk and the whole beaten and stirred till a perfectly smooth thin fluid was obtained. This was filtered through bags, and, after the fluid had passed through, the bags and the contents were allowed to dry spontaneously at an airy window for thirteen or fourteen weeks. Red ink, or, rather, a red paint, was made from finely powdered vermilion mixed by an elaborate process with white of egg. This was a general method for the utilisation of natural mineral colours: they were ground and sifted, or elutriated and dried—the operations being repeated as often as was deemed necessary,—and then the colour was used with gum water or white of egg. Green and blue colours from copper and white lead are mentioned.

Vegetable colours were extracted from flowers and from coloured woods, Brazil wood being frequently employed. This was boiled, strained, and treated with alum and lime, or with ammoniacal urine. A "lake" was formed, which was applied with gum water. Different shades were got by varying the proportions, or by mixing the colours.

A few artificial colours were made. Mosaic gold—*Aurum Musicum*—is very carefully described. Tin amalgam was heated with sulphur and sal ammoniac, the product thoroughly ground and used with gum water.

Gold was prepared for gilding by grinding the leaf gently for a long time in successive small quantities with salt and strong gum, made of the purest gum arabic and distilled or rose water. Much trouble was expended in getting the gold into the finest state. Several sections are devoted to the laying on of gold, the gilding of books, the colouring of parchment for receiving gold and silver writing, and other fine arts.

The directions give some insight, though not nearly enough, into the methods and materials of the old illuminators, whose

work seems to-day as brilliant as when it was first executed, and the results they attained show that work which is to be permanent must have much time and thought and labour expended in its production.

- 15.—1583. A profitable booke | declaring dyuers approoued re- | medies, to take out spottes and staines, in Silkes, | Veluets, Linnen and Woollen | clothes. | With diuers colours how to die Vel- | vets and Silkes, Linnen and Woollen, Fustian | and Threade. | Also to dresse Leather, and to co- | lour Felles. How to Gylde, Graue, Sowder, and Ver- | nische. And to harden and make softe | Yron and Steele. | Very necessarie for all men, speciallye for those | which hath or shall haue any doinges therein: with | a perfite table herevnto, to fynde all | thinges readye, not the like reuealed | in English hereto- | fore. | Taken Ovt Of Dytche, | and englished by L. M. |

¶ Imprinted at London by Thomas | Purfoote, and William Pounsonbie. | 1583 |

Small 4to. Title leaf, and pp. 78. Table, pp. [6]. Printed in black letter.

The preceding is from the copy in the British Museum (C. 31, c. 18), and I presume it is the first edition of this translation. It was reprinted in 1596, No. 17, and again in 1605, No. 20, each succeeding edition being inferior to its predecessor. An account of the contents is given under No. 17, 1596.

- 16.—1589. Alchimia, | Das ist, | Alle Far- | ben, Wasser, | Olea, Salia, | vnnd Alvmia, | damit man alle Corpora, Spiri- | tvs vnnd Calces Prepariert, | Sublimieret vnnd Fixiert, zubereyten. | Vnd wie man diese ding nutze, auff | dass Sol vnd Lvna wer- | den möge. | Auch von Soluieren vnnd | schey- | dung aller Metall, Polierung, allerhandt | Edelgestein, furtrefflichen Wassern zum Etzen, | scheyden vnnd Soluieren. Vnnd zuletzt wie die | giftige Dämpff zuverhüten, ein kur- | tzer bericht, &c. | Cum Gratia & Priuilegio Imperiali. |

Getruckt zu Franckfort am Mayn, |

M.D. LXXXIX.

Small 8vo, ff. 79 [1]. Pictures of furnaces, flasks, and other apparatus. The title is printed in red and black.

Colophon:—

Zu Franckfort am Meyn, Bey | Christian Egenolffs Erben. |

This is the fourth issue of Kertzenmacher's book. See Nos. 5, 1539; 9, 1570; 12, 1574; 21, 1613; 26, 1720; and 29.

- 17.—1596. A profitable booke | declaring dyuers approoued re- | medies, to take out spotts and staines, | in Silkes, Veluets, Linnen, and | Wollen Clothes. | With diuers colours how to die Veluets | and Silkes, Linnen and woollen Fustian | and Threade. | Also to dresse Leather, and to colour Felles. | How to Gild, Graue, Sowder, and

Vernishe. | And to harden and make soft | Yron and Steele. |
 Very necessarie for all men, specially for those | which hath or shall
 haue any doings therein: with | a perfect table hereunto, to find all
 things | readie, not the like reuealde in Eng- | lishe heretofore. |
 Taken Ovt Of Dvtche, | and Englished by L. M. |

¶ Imprinted at London by Thomas | Purfoot, dwelling in the newe |
 Rents. 1596. |

Small 4to. Title leaf; pp. 78, numbered; Table, pp. 6, not numbered,
 followed by a blank leaf. Printed in black letter, except the title-
 page and the titles of the different receipts.

This edition, which is not in the Museum, is a simple reprint, on inferior paper and with less distinct type, of the edition of 1583, contained in that collection, and already quoted, No. 15.

The treatise falls into two main parts: the first, pp. 1-58, contains receipts for taking out stains, for dyeing and colouring, and for dressing leather; the second, pp. 55-78, deals with iron and steel, etching on metals, gilding, and soldering.

The receipts for removing spots and stains are numerous, but they are mere modifications and variations of a general process, depending on the fabrics, and in a few instances on the kind of stains. Grease spots were removed by ashes, or oil of tartar, or a mixture of lime and ashes. "Walkers claye, called Fullars earth," is mentioned, and burnt alum mixed with soap. Ink and iron spots were treated with the juice of a lemon, or very sour orange, or crab apple, or with common salt and juice of an orange, or the boiling juice of sorrel. Oily spots in paper were got rid of by putting over them a layer of well burnt bone ash and pressing between two hard boards for eight-and-forty hours. A way to take wax and rosin spots out of cloth was to drop tallow on them, and then placing brown paper over the spots, to apply a hot iron till the rosin and tallow melted together and were absorbed by the paper.

Perfumes for clothes are described; and to keep away moths a powder of dried orange peel and elecampane root was recommended.

The receipts for dyeing are similar to those already so often quoted. The substances employed were woad, Brazil wood, "grening weede," indigo, oak bark, galls, verdigris, copperas, iron scales, alum, arsenic, ashes, and a solution of chalk in vinegar mixed with alum, which shows at how early a period acetate of alumina was in use. A considerable number of shades were obtained. All these receipts are very clear and exact. Skins were treated with lime and alum, and coloured with copperas,

madder, Brazil wood, and other substances; and a method of gilding leather is also given.

The contents of the second division are metallurgical. Numerous methods are described for softening and hardening iron and steel, some of which are to be found in the 1537 edition, No. 3. There are also receipts for soldering iron, varnishing it, preparing it for gilding, etching upon it. Most of these also have been already met with in the 1537 edition.

This work has been translated from Dutch and not from German; but, if it be not a compilation as well as a translation, I am not acquainted with any edition in either language of which is an exact transcript. If the two divisions have been taken from different sources, the second would correspond with the first tract in the 1549 edition, No. 6, so far as it goes, for the English version is fuller; but there is nothing in any of the editions to correspond in extent and detail with the first division about cleansing and dyeing.* This confirms me in the belief that the present list does not exhaust all the extant variations of the series.

18.—1596. A | Booke of Secrets: | Shewing diuers waies to make and prepare all | sorts of Inke and Colours: as Blacke, White, | Blew, Greene, Red, Yellow, and other Colours. | Also to write with Gold and Siluer, or any kind of Mettall | out of the Pen: with many other profitable secrets, | as to colour Quils and Parchment of | any colour: and to graue with | strong Water in Steele | and Iron. | Necessarie to be knowne of all Scriueners, Painters, | and others that delight in such Arts. Translated out of | Dutch into English, by W.P. |

Hereunto is annexed a little Treatise, | intituled, Instructions for ordering of Wines: | Shewing how to make Wine, That it may continue | good and faint not, Neither become sower, nor loose colour. And | how you may remedie faint Wine, take away the hoari- | nesse, with other instructions for the pre- | seruation of the same. | Written first in Italian, and now newly translated | into English, by W.P. |

London, | Printed, by Adam Islip for Edward | White, and are to be sold at his shop | at the little North dore of Pouls, | at the signe of the Gun. | 1596.

Small 4to. No pagination, but it contains ff. 19. Black letter.

The title of this rare pamphlet is from a copy in the British Museum. The first tract is a translation of the *Ettliche Künste*, No. 8, 1563, but it includes only the sections relative to inks and colours. Some of the methods for making colours, and all about

* It may be possibly a translation in full of the *Kunstbüchlein* of 1532, No. 2, which I have not seen, or of a Dutch version of it.

cleaning silk and dyeing leather have been omitted. The translator's name was W. Phillip.

The second tract has no connection with the other or with the present series.

19.—1600. Een schoon Trac- | taet van sommige werckingen | der Alchymistische dingen, om Gout, Sil- | ver ende oock van alle calcioneringe der Planeten, | ende andere Materien, Waterē ende Olyen der sel- | ver te maken. Item noch een Tractaet boecxken, | inhoudende van alderley Verwen te maecken, ende | oock hoemen alder leye Verwen wryven en leggen | sal. Ende is seer goet ende profytelicken voor al- | len Schryvers, Schilders, Conterfeyters en | andere Stoffiēders. Oock allen Lief- | hebbers der Consten. |

Noch een schoon Konst-boec, seer | nutlick voor allen Werclieden, als Munt- | meesteren, Goudtwerckers, Scheyderen, Goudt- | smeden, Schilderen ende allen Wercklieden, wer- | kende in Stael, Yser, Koper, ende alle ander Meta- | len. Item om alderhande plecken wt te doen. Om | alderhande coleuren te verwen. Van vergul- | dinghe ende versilveringhe. Ende van | werckinge der Alchymistiaschen | dinghen, etc. | Ghecopuleert ende te samen ghebracht | door Symon Andriessen van | Amstelredam. |

Ghedrukt t'Amstelredam, by Cornelis | Claessz opt Water int Schrijf-hoeck. | Anno 1600. |

Small 8vo. First book, ff. xxvj; Second book, ff. xxvj. Contents, ff. [4]. It is printed in black letter.

This is a conjoined issue of the two preceding Dutch versions and it is in two books. Book I. is a reprint of the 1581 edition, No. 14, and it consists accordingly of two tracts. The first begins: "Eerst om Goudt wt Mercurio te maecken," and ends: "Hoemen dat Gout gradiert," and it is a reprint, therefore, of the sixth tract in the edition of 1549, No. 6. The second tract relates to the making and using of colours, of which, as has been already shown, the first appearance was in the 1581 edition.

The second book has a separate title-page as follows:—

Const-Boeck: | Nieulijck wt den | Alchymistischen gront vergadert. | Tracterende van alle grontlijcken | ghebruyckinghe der Consten. | Nutlijck voor allen Wercklieden, als | Muntmeesteren, Goudtwerckers, Scheyderen, | Goudtsmeden, Schilderē ende allen Wercklieden, | werckende in Stael, Yser, Koper ende alle ander | Metalen. Item om alderhande plecken wt te doen. | Om alderhande colueren te verwen. Van ver- | guldinge ende versilveringhe. Ende | van werckinge der Alche- | mistiaschen dingen, etc. |

Ghecolligeert ende eensdeels ghetranslateert, door | Symonem Andree van Amsterdam. |

Niemandt en haet die Konst, dan | die onwetende. | Ghedrukt, Anno 1600. |

This title is a reprint with two or three additions of that of 1549, No. 6, and this second book contains the first five tracts of that edition, the sixth tract having been put in the preceding book. It is a somewhat curious arrangement, and looks as if the compiler had had both the 1549 and 1581 editions before him, but instead of reprinting the 1549 copy as it stood, and making a seventh tract of the section of receipts about colours from the edition of 1581, printed off first the 1581 copy, and then added the remaining tracts from the earlier edition. The result of course is the same, although the arrangement is inverted. This is the last edition in Dutch, so far as I know; if there were any later no mention of them and no examples have come under my notice.

- 20.—1605. A | Profitable | Booke, declaring diuers approo- | ued Remedies,
to take out spots | and staines in Silkes, Veluets, Linnen | and Woollen
Clothes : | With diuers Colours how to die | Veluets and Silkes,
Linnen and Woollen, | Fustian and Thread : | Also to dresse Leather,
and to colour | Felles. How to guild, graue, sowder, and ver- | nish.
And to harden and make soft | Yron and Steele. | Verie necessarie for
all men, specially for those | which haue or shall haue any doing
therein : with | a perfect Table hereunto, to finde all thinges rea- |
die, not the like reuealed in Eng- | lish heretofore. | Taken out of
Dutch, and Englished by L.M. |

Imprinted at London by Thomas | Purfoot, dwelling within the new
| Rents, in S. Nicholas Shambles. 1605. |

Small 4to. Title leaf, and pp. 78. Table, pp. [6]. Black letter.

The collation is from the copy in the British Museum, C. 31,
c. 20.

This is another page for page reprint of No. 15, 1583, but it is
as inferior to the 1596 edition as that is to the edition of 1583.
The paper is very poor, the printing wretched. Deterioration,
however, in the quality of successive reprints of a book seems,
from the numerous instances which have come under my notice,
to be the rule.

- 21.—1613. Alchimia, | Das ist, | Alle Farben, | Wasser, Olea, | Salia, vnd
Alvmina, damit man | alle Corpora, Spiritvs vnd | Calces Præparirt,
Sublimirt vnd Fi- | xirt, zubereyten. Vnd wie man diese ding |
nutze, auff dass Sol vnd Lv- | na werden möge. | Auch von Solviren
vnd Scheidung | aller Metall, Polierung allerhand Edelgestein, für- |
trefflichen Wassern zum Etzen, Scheiden vnd Sol- | viren : Vnd
zuletzt wie die giftige Dämpff zu- | verhüten, ein kurtzer Bericht,
&c. | Cum Gratia & Priuilegio Imp. |

Franckfurt am Mayn, in verlegung Vin- | centii Steinmeyers, Jm
Jahr | MDCXIII.

Small 8vo, pp. 130; Index[3]; Colophon[1]; 2 blank. The title is printed in red and black, and pp. 7-15 are taken up with pictures of furnaces of various kinds. The colophon runs thus: Gedruckt zu Darmstadt, bey Bal- | thasar Hofmann, in verlegung Vin- | centii Steinmeyers: | Jm Jahr MDCXIII. | The device is an altar with fire upon it.

This is another reprint of Kertzenmacher's book, No. 9, 1570. See also No. 26, 1720.

- 22.—1616. Kunstbüchlein | auff mancherley weiss Din- | ten vnd aller handt Farben zu berey- | ten. Auch Goldt vnd Silber, sampt allen | Metallen auss der Federn zu schreiben, mit viel an- | dern nützlichen Künstlein Schreibfedern vnd Per- | gament, mit allerley Farben zu farben. Auch | wie man Schrift vnd Gemälde auff | Stäglene, Eisene Waffen, | vnd dergleichen | Etzen soll. | Etliche zugesetzte Kunststücklein, vor- | mals indruck nie aussgangen. | Allen Schreibern, Brieffmalern, | Sampt andern solcher Künsten Lieb- | habern, gantz lustig vnd frucht- | bar zu wissen. |

Gedruckt zu Cöllen, Bey Peter von | Brachel, vnder der Gulden Wagen | Jm Jahr 1616.

16mo, or very small 8vo. Pp. 43. Inhalt, pp. [3]. Title red and black. Pagination very irregular.

Colophon:—

Gedruckt Cöllen bey Peter von | Von (*sic*) Brachel vnder der Gulden | Wagen. Jm Jahr 1616. |

There is a copy of this in the British Museum [1037, a. 10 (3)]. It is a reprint of the *Etliche Künste*, No. 8, 1563, and is therefore composed of excerpts from the 1537 edition. Like the earlier issue of 1563, it contains the section on leather dyeing, but that upon removing spots and stains from silk, &c., is not included.

- 23.—1637. Les Secrets Dv Seignevr Alexis Piemontois. Reuen, et augmenté d'une infinité de rares Secrets. A Roven, chez Iean Berthelin, dans la Cour du Palais. M.DC.XXXVII.
Small 8vo, pp. 675; Table, 70.

This is a reprint of Landré's edition of 1573, No. 10, and accordingly it includes (pp. 564-631) the French translation of Andriessen's *Kunstboek*, divided, as in the previous issues, into six tracts. It is a shabbily got-up book, badly printed on poor paper, and apparently meant for circulation as a chap-book.

- 24.—1687. Kunst-Büchlein, | Oder | Gründlicher Gebrauch von | Etz- Arbeit, in und ausserhalb | Feuers aus Alchymischen | und natürlichen Grunde, | Nehmlich, | Härten, Weichen, Schmelzen, | Scheiden, Abtreiben, Probieren, | Löten, Etzen, Abformen, | Abgiessen, &c. | Wie auch | Jede Farben zubereiten, erhal- | ten, bessern und wieder

bringen : | Als | Zum Mahlen, Schreiben, Illu- | miniren, Vergulden,
Stücken, | Edelgesteinen. | Nebenst beygefügetem Register. |

Franckfurth und Leipzig, | Verlegts Johann Caspar Meyer, | Anno
1687. |

24mo, pp. 203 ; index [9], 4 blank.

This is a reprint, in somewhat modernised language, of the edition of 1537, No. 3. It contains an additional paragraph on preparing a red colour from Brazil wood, corresponding to that in the *Ettliche Künste*, of 1563, No. 8.

25.—1691. In the British Museum there is another edition of the French translation of the Secrets of Alexis, printed at Rouen by "Jean-Baptiste Bensongne, rue Ecuyere, vis-à-vis la petite rue (sic) S. Jean, au Soleil Royal. M. DC. XCI." in 8vo. The translation of Andriessen's *Kunstboek* is contained in pp. 602-670, divided, as usual, into six tracts. It is a very scurvy volume, inaccurately printed, also in chap-book style, inferior even to the edition of 1637, No. 23.

26.—1720. Des berühmten | Alchimisten, | Petri Kertzenmachers, | Alchimia, | Das ist | Alle Farben, | Wasser, Olea, Salia und | Alumina, | Damit man alle Corpora Spiritus und | Calces preparirt, sublimirt, und fixirt, | zu bereiten, | Und wie man diese Dinge nutze, | Auf dasz Sol und Luna | werden möge, | Auch von Solviren und Scheidung aller | Metall, Polirung allerhand Edelgesteine, fürtreffli- | chen Wassern zum Etzen, Scheiden und | Solviren. | Dem noch beygefüget | Ein kurtzer Bericht, wie die giftigen | Dämpffe zu verhüten. | Anno 1720. |

Small 8vo, pp. [2], 109; Index [3]. The title is printed in red and black.

This is a reprint of the edition of 1570, No. 9, and it tallies with those of later dates. The differences are in the insertion of Kertzenmacher's name in the title-page, and in the omission from this edition of the short explanation of certain Latin technical words which are found in almost every version of these receipt books from that of 1531 downwards. The woodcuts of the different furnaces have also been omitted from the present issue.

27.—(15—?). In the British Museum [1036. a. 10 (4)] there is an earlier edition of the 1616 *Kunstbüchlein*, No. 22, or of the *Ettliche Künste*, No. 8, 1563. It is a small square 16mo, pp. I-XXXV, Inhalt, pp. [2], followed by a blank page. The title-page is wanting, so that I have been unable to ascertain the exact date: the colophon is as follows:—

† Gedruckt zu Augspurg durch | Hans Zimmerman. |

This little treatise contains, of course, the receipts on inks, gold and silver illuminating, colours, etching, &c., which are to be found in the 1537 edition.

28. —? In the British Museum [1036. a. 10 (2)] there is an imperfect copy in square 16mo, of some earlier issue of the *Kunstbüchlein*, 1687, No. 24. The title is wanting, as well as about a dozen leaves at the end, so that nothing definite can be said about the date or place of printing. From its appearance, however, it was probably printed early in the 17th century, if not in the 16th. The fragment consists of ff. 2-76, and the contents correspond as far as they go with those in the aforesaid 1687 edition. Practically therefore this is a fragment of another edition of No. 3, 1537.
- 29.—Sec. XVII. In a small 12mo volume I have a MS. on paper, of what is Kertzenmacher's treatise, although that person's name is nowhere mentioned. It contains 118 leaves numbered, and one not numbered. Comparison with the edition of 1570 shows that while it corresponds with the contents of that edition, it does not agree with it absolutely word for word. In some places, also, variations on certain of the processes are omitted, but practically the contents of the two volumes are identical. In the MS. version the tract by Gilbertus Cardinal on the solution of the metals is omitted, and instead of it are given a number of other receipts on the preparation of common salt, green and white vitriol, borax, sal ammoniac, tartar, verdigris, on gold, mercury, silver, arsenic, sulphur, marcasite, and other substances, some of which are to be found in the 1537 edition, while others do not occur in the printed copies so far as I have observed. The copyist has evidently thought it desirable to supplement Kertzenmacher's collection.

§ 3.—The results of this bibliographic sketch may now be summarised.

The first edition appeared in 1531. In 1532 was published the book about removing spots and stains from cloth, and these two were conjoined in the 1537 edition, certain other receipts about metals being prefixed. Kertzenmacher, in 1539, made a selection of the receipts specially relating to transmutation as he thought. In the Dutch translation of 1549 the matter was divided into six books; all about inks and colours was omitted; and the sixth book, relating to metallurgy, was enlarged. In the 1581 Dutch reprint of this sixth book a new tract on colours made its first appearance. Lastly, the English translation of 1583 added largely to the parts relating to cleaning and colouring. The remaining editions are either reprints or translations, in whole or in part, of the preceding types.

§ 4.—The mere enumeration, however, of these books, and recapitulation of the notions and methods of a long bygone chemistry which they preserve, would be of small value if some general principle were not illustrated by them as well.

One feature of them, which stands out strongly and strangely,

is their authors' ignorance or quite rudimentary conception of the properties of material objects. Substances were employed for a given purpose, apparently without certainty that they could produce the effect wanted, or, if they did, how the effect was produced. The receipts are empirical, and if they sometimes hit the mark it is more by chance than by good guiding.

That matter could be depended on, that a substance was individualised by its properties, seems hardly to have had any weight with the compilers of these receipts. They appear to have thought that the properties were variable, or could be extracted from a body, and so we meet with such a statement as that sal ammoniac *draws the colour out of copper*. From the way the author puts it, one feels in doubt if he knew the difference between gold and a yellow alloy. He certainly did not know that if gold is got out of mercury or lead, it must be there to begin with, and is not made by the process. There was no idea of combination or of chemical action as involving alteration of properties. Bewildered by changes to which he had no clue, with phenomena passing constantly before him which he could not control or produce at pleasure, the technical chemist fell back upon empirical trial, and so put a stop to progress. For empiricism is due to ignorance of the rationale of a process.

Wherever that ignorance exists a process must be imperfect; what is unessential is as likely to be included as what is indispensable, for there is no certainty about either one or the other. Hence in the receipts there are details which could have no bearing on the result, and operations are repeated with great expenditure of labour, time, and material, which, if they had been understood, would have been finished more speedily and economically.

§ 5.—So it happens that these books and their contents illustrate what I have said in the other paper* about the progress of the arts relying on mere practice, as compared with that based on inquiry into causes. The receipts give us insight partly into the manipulation of the old chemists and partly into the experience of others that they were the best to be got, and that the employment of them constituted the "right use of Alchemy"—something of *practical* use, as we hear about even now, as distinct from the examination of the phenomena and laws of nature. That these

* The paper meant is on *The First History of Chemistry*, read the same evening as the present one, and printed in the *Proceedings* for 1885-86, vol. xvii. See p. 222.

receipts were appreciated is evidenced by the demand for the books and the number of editions of them. Their persistence is one of their characteristics.

But if anything could illustrate the unsatisfactoriness of empirical methods it would be the contents of the books. For these practical receipts never got any further. They were reprinted *word for word* in 1687 as they had been set forth in 1531 and 1537, and in 1720 as in 1539 and 1570; that is, they existed and were repeated without even verbal change for 150 years.* The collections were varied by omissions or additions of receipts; but the retained receipts were not altered or improved. The science of chemistry had, meanwhile, gone past them, and other books, like those of Beguinus, Glaser, Glauber, of Becher and Stahl and Boerhaave, had been published, which threw new light upon chemical processes, and enabled them to be carried on in a more rational way, and, as a natural consequence, with ever so much better results.

If there were not constant evidence of the vitality of error, one might feel offended at what was considered a secret in practical art worth knowing at the beginning of the sixteenth century, being thought of equal value in the eighteenth, and being republished, unchanged, for the benefit of those who cared to use it. In our days a process can hardly continue for even a short time without its undergoing some modification. So widely diffused is the knowledge of natural science, so irresistible is the ambition to discover something unknown, so rapidly do theories change with new facts, so pressing is the demand for the application of discovery to human uses, that it would be impossible merely to reprint any work on pure or applied chemistry, even were it but two or three years old. It is difficult, therefore, to conceive the state of experimental science when a treatise of applied chemistry could still be of use 150 years after its first appearance. Such slow progression is hardly intelligible, unless we remember that there were receipts, trade secrets, jealously guarded, but no real science, no knowledge of the laws of nature which could be applied to make man's existence easier. Society besides had its attention directed in quite different directions, and was not fitted

* They, however, are not the only examples of literary longevity. Even more remarkable cases are described in my *Notes on Books of Secrets*, parts IV. and V., in the *Transactions of the Archæological Society of Glasgow*.

for the physical amenities of the present time. So far as chemistry was concerned its principles were too narrow and too inaccurate to permit of technical applications of them. The latter had to wait until the science had grown, by slow correction of its errors, to a fuller comprehension of its own scope. The history of technical chemistry shows that the only foundation for progress in practical applications and production lies in scientific investigation and in the employment of principles and laws; not in "rule of thumb," however absolute; not in haphazard discovery, however lucky and brilliant; not in mere practical dexterity, however consummate. Even if an epoch-making discovery be found by random search, its value is not understood until it has been brought under the law of its being. Priestley isolated oxygen, the most important of all bodies; but he was unable to deduce any law or generalisation from it, and to the end of his life he never grasped the significance of his own work; oxygen remained barren in his hands. Prussian blue, discovered by the merest accident, was manufactured empirically with the utmost uncertainty, until Scheele inquired into the cause of the blue colour, and demonstrated what substances are absolutely necessary for its production. Thereafter the manufacturer could proceed with rapidity and certainty. Coal tar, practically produced, was, as an utterly offensive product, practically wasted, until scientific investigation showed practice what can be done with it, what can be made of it. The coal tar industry, in its very widest form, rests on science, not on practice. Had not chemists pursued the examination of the substances in coal tar, merely for the sake of knowing them and without any intention of practical application, the coal tar colours would never have been discovered, and the series of manufactures thereon depending would never have been called into existence. Every industry that has truly progressed has acquired, sooner or later, to a greater or less extent, a scientific foundation. The history of the manufacture of sulphuric acid exhibits the economy of scientific working, as compared with that of mere practice.

No more hampering, no more fatal delusion can exist than that science is inimical to practice—that the manufacturer does not need science. If that has any meaning, it is that the producer on the large scale can get on better in his dealings with matter by ignorance of its laws than by knowledge of them; that he can afford to neglect them on the large scale, while the scientific investigator must obey them implicitly at any cost.

This is self-contradictory, and it is shown to be so by history. No thesis is easier to maintain or easier to illustrate than that the mere manufacturer is at the mercy of him who makes discovery his chief aim, and must follow wherever he leads. If it required anything to show how all-important is science to the progress of technology it would be the contemplation of the first attempts at technical or applied chemistry as recorded in these old books.

VI.—*The Heeling Error of the Compass in Iron Ships.*

By WILLIAM BOTTOMLEY.

[Read before the Society, 11th January, 1888.]

IN this paper I do not propose to enter into the general question of the magnetism of an iron ship and the errors of the compass which it produces, but will confine myself to the consideration of the disturbance which is experienced when the vessel "heels" over. I will assume that, with the ship on an even keel, the effect of the magnetism of the ship's iron on the compass has been compensated by Airy's well-known plan of placing magnets fore-and-aft and thwartship, to correct the semicircular error, and masses of soft iron on each side of the compass, for correcting the quadrantal error, and that the compass is correct on all courses when the ship is on an even keel. When the ship heels over, the altered position of the iron of the ship produces a change in its effect on the compass, and gives rise to the "heeling error." The *general* effect of the heeling of the ship is to produce an error which is greatest when the ship's head is north or south, and which gradually diminishes as the ship veers round towards the east or west. With the ship's head east or west there is no sensible heeling error. In general, when the ship is in the northern hemisphere, the north point of the compass card is drawn to the high side of the ship; in the southern hemisphere it is drawn to the low side of the ship. The disturbance due to heeling arises from two separate causes:—(1) The component of the ship's permanent magnetism which is perpendicular to the deck; (2) the magnetism induced in the soft iron of the ship by the vertical component of the earth's magnetism.

The special object of this paper is to deal with the error which is produced by the second of these causes, that is to say, by the magnetism induced in the soft iron of the ship by the vertical component of the earth's magnetic force, and to show that the masses of soft iron which are placed on each side of the compass, to correct the quadrantal error when the ship is upright, exercise

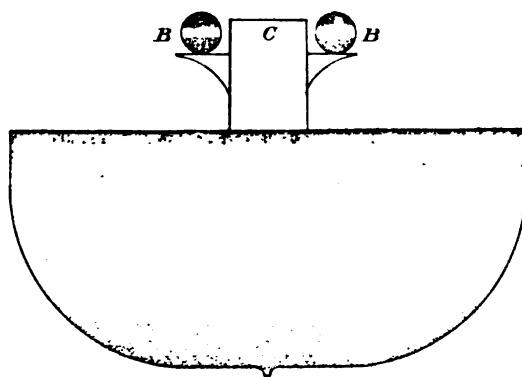


Fig. 1.

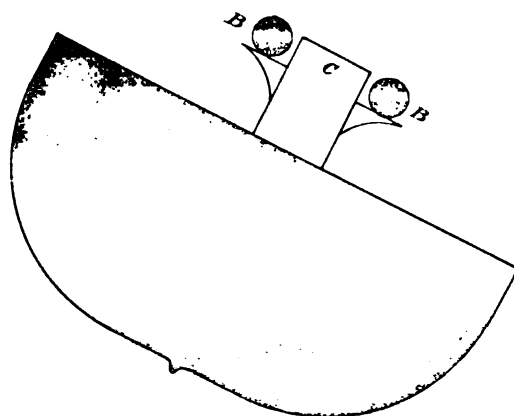
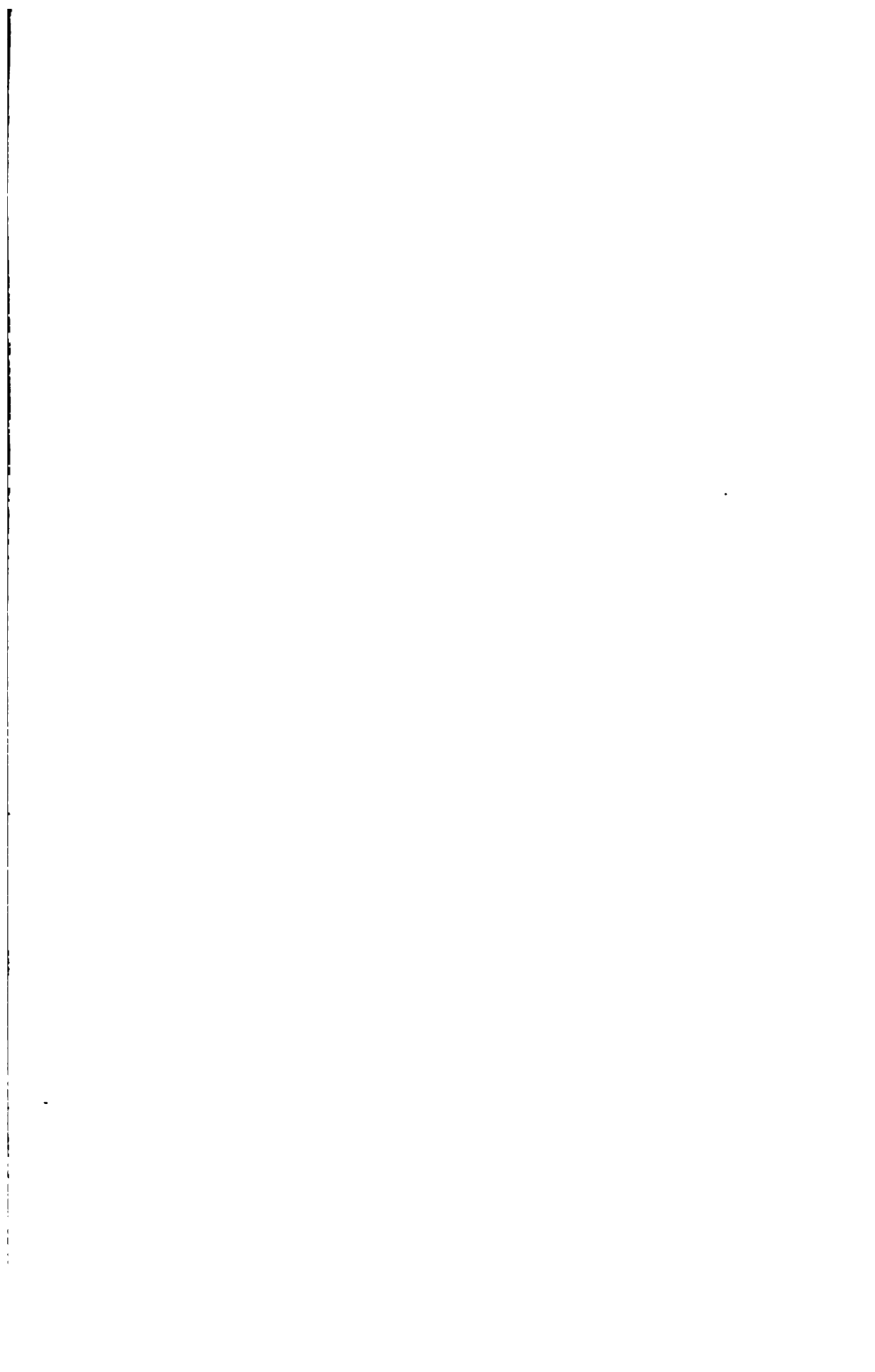


Fig. 2.



a most important part in correcting the heeling error when the ship heels over if they are fixed to the binnacle and move with the ship.

I have spoken of the magnetism induced in soft iron, and perhaps it would be desirable for me to explain very briefly the terms "hard iron" and "soft iron," and the effects produced by magnetic force on these different kinds of iron. "Soft iron" is iron which becomes magnetised almost or quite instantaneously when brought under the influence of a magnetising force, and which loses its magnetism as soon as that influence is removed. "Hard iron," on the other hand, is iron which does not acquire magnetism so easily, but when once it is magnetised it retains its magnetism even when the magnetising force is removed. I have here a bar of soft iron with which I will illustrate the effect of magnetism on soft iron. When I hold it in a vertical direction, or in the direction of the "dip," it is brought under the influence of the earth's magnetic force, and it at once becomes magnetised; the upper part attracts the north-seeking end of this suspended needle, and the lower part the south-seeking end of the suspended magnet. Now, if the bar be reversed end for end, its magnetism will at once become reversed. The lower end of the bar, which was uppermost before, and attracted the north-seeking end, now repels it and attracts the south-seeking end. When the bar is held horizontally, with its length in an east and west direction, it loses its magnetic effects if it is perfectly soft.

On the other hand, a piece of unmagnetised hard steel will not become magnetised unless acted on by a powerful magnetic force, but when it has been magnetised by a sufficiently great force it retains its magnetism permanently.

The iron used in shipbuilding is neither perfectly hard nor perfectly soft, and in consequence we find the effect both of hard iron and of soft iron on board an iron ship. By the hammering in rivetting the iron of the ship becomes partially magnetised, so that the ship acts as a permanent magnet, but at the same time the iron of the ship also exhibits the properties of soft iron, and becomes magnetised by induction from the earth's magnetism. This diagram (Plate I., Fig. 1), which represents a cross section of a ship in the northern hemisphere at the position of the compass, illustrates the distribution of magnetism induced in the soft iron by the vertical component of the earth's magnetism.

The whole of the upper part of the ship acquires magnetic polarity similar to that of the earth's North Pole—coloured blue,—while the lower part acquires polarity similar to the earth's South Pole—coloured red. Now, when the ship heels over (Fig. 2), this induced magnetism shifts in position in the ship. The upper side of the deck becomes more powerfully blue than the lower side and attracts the north point of the compass towards it, and produces a heeling error, drawing the north point of the compass to the high side of the ship. In the southern hemisphere the opposite effect will be found. The upper part of the ship will acquire magnetic polarity similar to the earth's South Pole, and when the ship heels over the upper part of the deck will repel the north point of the compass and cause a heeling error, drawing the north point of the compass to the low side of the ship.

I wish now to show you that the soft iron correctors, which are used for correcting the quadrantal error when they are fixed to the binnacle and move with the ship, exercise a most important part in correcting the heeling error when the vessel heels over. These masses of soft iron are shown in the diagram at B, B, and are placed on each side of the binnacle, C. They are made of soft iron, and become magnetised by induction from the earth's force. The upper part acquires blue polarity, and the lower red polarity. When the ship heels over, the lower part of the quadrantal corrector on the upper side of the ship rises up towards the level of the compass needles, and having red polarity, it repels the north point of the compass from the high side of the ship, and thus acts as a most important corrector for the heeling error.

With regard to the amount of this correction, I may say that globes of soft iron, $8\frac{1}{2}$ inches in diameter, when placed about 8 inches from the centre of the compass correct about 7° of quadrantal error. This is a very usual amount on board a merchant ship. These globes will correct about 1° of heeling error for each degree of heel of the ship—that is to say, if the ship heels over 10° , the globes will correct 10° of heeling error. Notwithstanding this large correction of the heeling error, which is effected by the quadrantal correctors, it is found in practice that it is not sufficient to correct the whole of the heeling error, and it is necessary to apply a magnet perpendicular to the deck, underneath the centre of the compass, to augment the correction of the heeling error which is effected by the quadrantal correctors.

MR. NATHANIEL DUNLOP, on being called upon to speak by the President, said he had been much interested in Mr. Bottomley's paper, and in the explanation of the heeling error. He was sorry that there were so few nautical men present to see the illustration of the heeling error, which had been shown by means of the iron tank, and of the correction of the heeling error by means of the quadrantal correctors fixed to the binnacle. It had been proposed recently to correct the compass on board iron ships by correctors attached to the compass bowl and swinging with the bowl, but he thought that the explanation and illustrations which Mr. Bottomley had given proved conclusively that for the proper correction of the compass it was necessary that the correctors should be attached to the binnacle and partake of the motion of the ship.

VII.—*Public Museums as Aids in Teaching.* By JAMES COLVILLE,
M.A., D.Sc.

[Read before the Society, 11th January, 1888.]

I PROPOSE in the following paper to bring under the notice of the Society a plan for the better utilising of public museums and cognate institutions for purposes of ordinary school teaching, considering in the first place its bearings on education, and in the next place the probable effect of its adoption on museums themselves. Discussion will bring out the weak points of the proposal, determine the departments of teaching to which it is applicable, and give a direction to its further development.

Although most departments of educational work have been carried on in recent years under more favourable conditions than formerly, there is room and urgent need for a new departure in a direction in which our Corporation, as custodiers of Museums, Parks, and Galleries, can lend efficient aid. What I am about to say in support of this position is well foreshadowed in the following quotation from a paper, recently read before this Society by the accomplished Curator of the Museum. "During the past fifteen years," says Mr. Paton, "education has made enormous strides in our midst, and large sums have been expended in the machinery of elementary education and school buildings. We are now on the threshold of other important changes in connection with scientific and secondary education, and in the efficiency of all these educational movements the museum of the city ought to be an important factor. It ought to be the centre around which educational institutions should cluster, the storehouse whence they could draw the material examples and illustrations required on the lecture table and in the class-room."—*Proceedings of the Philosophical Society of Glasgow*, Vol. XVII., p. 77. .

Long convinced of the educative influence of museums, and desirous of making better use of them than was possible under existing conditions, I transmitted the paper I now read early last autumn to the proper authorities, requesting the privilege of

borrowing objects from their collections, but scarcely venturing to hope that my prayer would be conceded without a struggle. To my agreeable surprise I was met more than half-way. I had suggested that, on the lines of circulating libraries, schools might subscribe to the museum and thereby entitle themselves to borrow from time to time from its contents, subject to the discretion of the Curator. However, in a circular addressed to the Chairman of the School Board, the privilege was offered most generously to all schools without such subscription. As I have already made ample use of the privilege, I am in a position to speak of the benefits to be derived, and of the actual working of the scheme.

It is not necessary to recommend at great length such a scheme on theoretical grounds. If one feature more than another is specially characteristic of recent educational progress, it is the increasing importance assigned to things rather than words, to the concrete rather than the abstract, as an instrument of instruction. This, after all, is but the oldest and most natural of pedagogic methods. Lucid, simple explanation is good; diagram or picture still better; the actual sensible object best of all. What means this cry, as yet incoherent, for technical training but the expression of a feeling that the senses—the gateways of knowledge—form the safest basis for instruction calculated to prepare for the industrial business of life? What we have to do with here, however, is nothing more than the general education of the senses. This general education of the senses must necessarily have things rather than words for its instruments. Academic methods must ever remain indispensable to the training of the professional, learned, and governing classes; and in the olden days, when the resources of civilisation were few, and the field open to human effort limited, the need for such classes was paramount and their rewards great. No wonder then that these methods gained that firm hold on education which they so stoutly to this day maintain. No mere education of the senses will ever impart the subtle sense of the beauty of linguistic expression, the far-reaching grasp of the philosophical intellect, the noble enthusiasm of the statesman, the orator, the poet, and the preacher. On the vastly-preponderating class, however, of hand-workers in field and city, academic methods would be thrown away. Let them be strong with the strength of Antæus, greatest when in contact with mother earth. To all immature minds, unaccustomed to mental analysis and accurate linguistic expression, objective teaching is a philosophical necessity.

Seeing is not only believing, but it should create a desire to see as the best basis for belief, for the human mind rapidly grows in acquisitiveness and assimilating power when brought into intelligent contact with the facts of nature. How, then, is the demand for objective teaching to be satisfied? Pictorial art pours out to us endless stores of illustrative material. It may be that this very abundance tends to cramp the imagination and gratify a mere vulgar wonder. Excursions and collecting are still better educators. Country children are in this connection, for the more familiar objects of their districts, independent of further aid, and can see, handle, and collect, as part of their daily experience. Geikie's recent book on the Teaching of Geography as a stimulus and guide to this delightful hunting-ground of the senses is admirable in its wise suggestiveness. But with the urban child the case is otherwise. On the other hand, if we consider great industries and mechanical processes, the town youth has the advantage. To him the street, the wharf, the market, the railway station, are a living moving museum. Whether or not either makes good use of his natural advantages, finding in them a stimulus to his curiosity, is another matter.

Everyone is familiar with the all-important part which Bacon assigned to observation and experiment. Now, in the general education of the senses, museums play the part of experiment in supplementing and forwarding the slow process of individual observation. The formation of such in connection with the daily teaching of the school is most commendable. One of the most admirable features in the yearly report of a German higher school is the graceful and grateful reference to the various contributions, from pupils and well-wishers, of objects for the school museum. Any school collection, however, is necessarily imperfect, and, when the special interest in which it originated has evaporated, is liable to sink into melancholy neglect. We have therefore to fall back upon the public museums, and here the question arises—Do these quite satisfy the demand? A suspicion is apt to arise that they scarcely realise the expectations of those who believe in them. To most people they are shows, sights to be done, retreats in enforced leisure or stress of weather. The thousands whose visits the turnstiles tell feel no immediate need of education, and do not very well know how to set about the satisfying of such a want, supposing it to exist. How might such institutions be made educationally more valuable? The specialist is able to look after

himself; but the problem is, how to bring under the influence of museums and galleries those young minds in whom intellectual acquisitiveness is but imperfectly developed. The inner eye sees only what it has been taught to see; we take the liveliest interest in those who are likely to be of service to us, anyone of whom we have no need being to us supremely indifferent. I once saw, and the sight was a depressing one, an apathetic procession of children led through the Corporation Galleries at a quick but not very steady pace, to see the prize drawings in connection with the South Kensington examinations. Here was education by official authority reduced to a farce. In a German town the visits to Botanic and Zoological Gardens form an officially recognised feature of the school programme. In Hamburg and Berlin, for example, it is as familiar as it is delightful to see lads, on their way from school, sketching the artistically-constructed houses in the Zoo, either alone or with a master; or classes marching off in the early morning to supplement the instruction of the class-room. Why this should be so would lead one far afield into a comparison between German and Scotch children, and above all between the position of education and of the educator there and here. To have our schools brought to the museums is with us quite impracticable and indeed inexpedient, whether by teachers conducting their pupils thither, or by lectures within these institutions themselves.

How might the museum be brought to the school? This question is answered by the generous and enlightened offer of the Corporation circular. It is to be taken advantage of only on certain lines and within special limitations. Many instructive objects, from their size, nature, and value, are quite unsuited for lending. There would still remain plenty of useful material, particularly in the departments of natural history, economic botany, archaeology, the raw materials of art and industry, illustrations of commercial geography and missionary enterprise. Nor is it possible to forget that in actual working the scheme will call for system, patience, and kindness, on the part of the officials, and unflagging enthusiasm and industry on the part of the beneficiaries. On the former head, at least, there need be no apprehension with so enlightened a curator as Mr. Paton, and one so able and courteous as his assistant, Mr. Campbell.

To discuss the advantages of this proposal to schools themselves would lead to an exposition of the first principles of teaching. *Nihil in intellectu nisi prius in sensu* is an old dictum that puts the whole

matter in a nutshell. But the benefits to museums themselves would be considerable. The effect of educating through this channel the powers of observation will bring again and again to public collections inquisitive eyes that would never otherwise have looked twice at them. The direction thus given would lead to further developments. It would directly minimise their mere show aspect, and improve the scientific. One may see in Edinburgh the effect in this direction of a museum being directly associated with a great teaching institution. We have no such facilities for strictly scientific study, for schools and the general public are practically excluded from the Hunterian and Andersonian Museums—the only collections we have that exist specially for teaching purposes. The working of a school-lending scheme would no doubt soon reveal the defects of the Kelvingrove Museum in this connection. Take, for example, the department of natural history. The general educator does not look for specimens of the larger mammals—they are hardly worth the space they occupy; but he would expect to see illustrations of structure, especially in their comparative aspects, *e.g.*, illustrations of skull formation, dentition, foot, horn, and the like. We may well despair of ever seeing realised among us the enchanting pictures, sketched in a recent article in the *English Illustrated Magazine* on “Ornithology at South Kensington.” There one finds not only stuffed birds, but a family group—of parents, young, nest, and surroundings, the whole forming a perfect bit of nature cut out and fixed in its entirety before the admiring beholder. But there might easily be a comparative view of types of wing, feather, feet, beak, and the like. Take, again, Entomology and Conchology. Both are shown as a rule in the thoroughly dead and dreary style. Why should there not be, in addition to the orthodox cases for facility of naming and reference, groups showing the local forms at least, say of insects among models of the plants which they frequent, of molluscs in a bit of sea-cave, with weed and sand and shingle. Then, again, why speak of the transformations of insects when they are so rarely illustrated? Not only the imago, but its eggs, larva, and chrysalis ought to be shown together. It would be easy to find numerous illustrations of how museums would be developed educationally by their being used in actual school teaching. With this, again, is connected the matter of models. Anyone who has seen the Berlin Post-office Museum, or that of Hygiene, will know both how immensely behind the artistic Germans we

are in this respect, and how instructive beautiful models can be made. Could there be better or more valuable *Hand-Arbeit* for technical schools than the production of scientific models, many of which would find their way to a school-lending collection?

The principle of lending from public stores admits of wide application. Were there a custodier in the public interest, such as the Corporation, for maps, diagrams, photos, engravings, philosophical instruments, and the like, what a field of fresh, genuine instruction would there be opened up. The expense of purchase weighs heavily upon the few voluntary and proprietary schools that still survive, and in this way the children of the better classes positively suffer. To furnish a new map of Scotland for elementary (*sic*) instruction, the School Boards of Edinburgh and Glasgow have just ordered over 70 copies, at an outlay of about £150, which gives one some idea of the demands made on modern school-keeping. But it is impossible for even a rich city Board to make each school complete within itself. If it were so, it would entail enormous waste both of money and material, in addition to involving a gross mistake in principle. To stimulate and keep alive intellectual curiosity, there must be constant change of objects. Pictures soon become to the familiar gazer merely so much wall-paper. To the School Board, however, we might naturally look to fill up a gap in our educational machinery in a way that would be both interesting and instructive, for it might help us to a Museum of Pedagogy that should present a telling view of the history of education—the most important phase of social development. The appliances for instruction are many of them clever and ingenious; they tell of failure as well as success, and in both respects are suggestive. There is a public outside the school that it would be unwise, even under a rate-aided system, to ignore. It would be, moreover, graceful and thoughtful of a City Board to cultivate such neutral ground in a field, the major part of which it monopolises, and do something thereby at once to instruct and stimulate. For such a museum, if wisely planned, would be much more than an exhibition of school furniture. Sectional museums of this kind have a sound *raison d'être*, and will be in the future much more useful than the huge storehouses of the past. There are two such school museums in Berlin, but they belong to associations of teachers, and are necessarily on a limited scale.

Apart from Museums and Galleries the Parks and Gardens of

a city have an educational as well as a recreative value, as the only bits of nature left to us for the training of the observing faculty. A walk in the country under the terrible incubus of feudalism bristles with warning notices against trespass to right or left. There is some excuse for this in the conduct of city excursionists, but it is to be hoped that a youthful population, educated to take an intelligent interest in nature, to love it, and to study it, would soon make this brainless vandalism a thing of the past. Meanwhile, till that happy day arrives, what may be got out of our preserved nature in towns? In our parks something more should be aimed at than greenery and good roads, our Botanic Gardens should not be considered merely as acres of glass and hundreds of unfamiliar exotics. These are excellent in their way, but it would be easy to mingle instruction with pleasure. Horticulture is a delightful luxury, but its nomenclature and forms are strange. In the parks we have pretty bits of this sort of thing, but the names of the plants excite little interest, and satisfy few wants. Let us have the trees and shrubs named, which would be more than was done in the so-called Botanic Gardens. Why not also cultivate little groups of our common flowers, grains, grasses, even the humble vegetables? Does the town child know how they all look when enjoying the life and liberty of mother earth, and her genial sky? Is not even a turnip leaf or a carrot top, a pea blossom or a potato apple, a graceful and interesting object? We err greatly if we think all these are well-known to the young. There are none so blind as those who feel no stimulus, find no occasion, to look. A thirst for knowledge is supposed to be synonymous with a love of books. Far from it; there is a cyclopædia of instruction around us, but we are too indifferent to learn. Only those who are engaged in teaching can realise how unobservant young people are. To them all herbs are grass, all grains corn. In an assembly of town-bred adults what percentage of them would be able to distinguish the different native forest trees in leaf? Still fewer would do so if, as Ruskin tells us to recognise our trees, they were to see these, among the most graceful of natural objects, merely as naked forms shown up against the cold sky of a winter twilight.

It will hardly be denied that, in the laying out of our parks and gardens, popular instruction was little thought of. Take, for example, the ornamental pond in the West-End Park. It has been planned on the model of a utilitarian reservoir, when it

might have been a pretty bit of nature. Naked whinstone blocks form its banks, and a commonplace island its centre. Had these been concealed with reeds and aquatic plants; had a few willow stumps been driven into the bottom of the pond, and vegetation allowed to cluster around them, not only would the eye have been pleased, but, what is more, the birds would have found that plant and animal life on which they thrive, and the balance of nature would have been established. Given a few holes on the sloping banks, a few reedy retreats on the marge of the mere, and on a calm summer morning the water-hen and the burrow-duck, the mallard and the teal, might be seen guiding their callow dots of golden green over the placid waters. Take, again, the enclosure, in which there are only a few sheep to remind us of our sooty abominations. How delightful would it be to see instead a rock garden in the centre of the grassy slope filled with alpine plants. These would be redolent of the breezy crags and heathery uplands of our youth, while the costly products of the greenhouse tell only of the gorgeous but unfamiliar tropics.

Parks and gardens, in common with museums, admit of a more precise use in connection with school teaching. In the subject of Botany, there is in towns very great difficulty in procuring specimens. It is fortunate for us that the Corporation now own the Botanic Gardens, and will, it is to be hoped, extend to them the privilege they have generously conceded to schools in connection with the Museum. Fancy the impulse that would be given to Botany, one of the most delightful of all the sciences of observation to the young, if a teacher could at any time draw upon the parks and gardens for illustrations in the class-room. Such a scheme is actually in operation in Berlin, where schools may subscribe to the Botanic Gardens, and in return receive specimens for teaching purposes.

The consideration of our parks and gardens naturally suggests the wider question of open spaces and innocent recreative resorts in such a large centre of population as our own. This subject was most thoroughly and suggestively treated by our President, in a paper read before the Edinburgh Health Society. There he drew attention to the influences tending to the gradual deterioration of urban populations, and among them not the least the absence of recreative facilities. With squares few, and school playgrounds shut, the young are driven to the crowded street; for the adult idler the drinking bar and the music hall have no

rivals. Contrast this with the kindly and intelligent interest in children one sees in a continental town. There, in squares and parks, we have the usual Spiel-platz with its heap of damp sand laid down for the tiny workers, and here and there stone benches on which to dispose the forms each has constructed. There are inherent racial differences between German children and our own; but may not the offensive rowdyism and unmannerly roughness so rampant among us be the penalty we pay for that freedom and individuality which leave the strong youth to find his pleasures for himself at the expense of the weak? There is yet another recreative resort of the highest educational value unrepresented among us. When may we hope to see zoological gardens, an aquarium, terrarium, aviary and the like, where animal life—the only perfect awakener of youthful human interest—may be studied and enjoyed? If the business enterprise of Glasgow could but witness the success and general attractiveness of many such places elsewhere, we should have them forthwith. They form an endless source of interest and instruction in—not to speak of the great capitals London and Paris—such cities as Berlin, Köln, Hamburg, and Rotterdam. Except the first-named, these are all far smaller places than Glasgow. Hamburg is almost the size of Edinburgh, Köln and Rotterdam each not much bigger than Dundee or Aberdeen. In all these places the collections are in pretty and attractive gardens, besides having in themselves a real scientific value. And what is the best feature of all about them, they exist without state aid. The Berlin Zoo was originally a Royal collection located at Potsdam, but was in 1844 transferred to the capital and handed over to a body of shareholders. On a cheap day last July (admission threepence) there was an attendance of 30,000. The garden in Rotterdam is on the basis of a company of shareholders, and further as a club, the members paying an annual subscription of 46s., with entry-money for the first year of 16s. 8d. None but members—of which there are several thousands—and strangers have admittance, except on a few days in summer, when townspeople are also admitted temporarily at 10d. each, workpeople paying 5d. The garden stands also very high as a botanical collection, and while it pays its expenses, which are very heavy, and interest on its loans, it is entirely and fully self-supporting. And all this in a population of 157,000. Could it not be imitated here? Even as things are a beginning might be made. The water-fowl in the parks form an endless source of

interest, even without any hint being afforded as to their names and habits. We can remember the time when even the solitary eagle attracted much attention. Would not the Botanic Gardens have been a greater success if animal life had been shown in them? The centre of the Kibble would allow of an aviary as large as that in the Berlin Aquarium, one of the most delightful and instructive resorts of the city. Of the long series of glass-houses one could easily be turned into a terrarium for reptiles, showing rare and interesting forms of snake, tortoise, and frog life. A rockery under glass, alive with the lovely lizards and odd-looking chameleons, would prove a constant source of delight. Scattered up and down the garden might be the cages of the larger birds of prey and the smaller mammals, a seal and otter pond, a picturesque enclosure with examples of goats, and deer, and so on. Lastly—one of the prettiest features of the Hamburg Zoo we might have, the Eulenberg, an imitation of a ruined castle, showing the various kinds of owls in quaint shady corners. Small kiosks here and there might exhibit the wonders of the microscope, optical marvels, and many popular aspects of Science. Under the spell of such imagining one pictures a happy future when we shall see a prosperous and educated city, an Improvement Trust improved out of existence, a School Board debt in a fair way to extinction, a river once again pure and limpid, the Laird of Blantyre and the Clyde Trust at peace and uniting to convert the Erskine policies into a magnificent people's park, full of every form of harmless pleasure and instruction. Picture such a scene in leafy June, thousands of pale faces invigorated by the woodland breezes sighing fresh amid nature's greenery; in front the eternal river flowing 'neath the grey rock where lies the memory of buried centuries; above, the lights and shadows of the Kilpatrick hills, and away in the far distance the silent Bens bathed in the opaline radiance of the evening sky.

But to return to the sober present. I am quite aware of the difficulties among us attending museum and gallery extension, the troubles of the much-afflicted ratepayer, and the problems of city expansion. I have considered merely what is probably realisable. What are the resources of Glasgow for the realisation of such a state of matters? As at once a great commercial and a great manufacturing centre, it occupies a unique position. To say nothing of our varied industries as a training ground for technical education, what has been called commercial geography

is both within the range of ordinary school work, and touches all departments of trade and commerce. Here is a wide field for the general education of the senses. With the assistance of our merchants and manufacturers, and their world-wide connections, it should be possible to form a display of raw materials that would leave nothing to desire. If the teacher could vivify the dry details of geography with a sight of the native products of our foreign customers, specimens of goods in demand among them, &c., would not this secure a distinct advance in a direction in which we are said to be paying the penalty of ignorance and indifference? The sight of objects illustrative of manners, customs, and beliefs, the handling of an assegai or a tomahawk, a calabash, or a fetish ought to inspire the youthful mind with a deeper conviction of the mysteries of human nature, and hasten the time when "man to man the world o'er" shall feel as brothers. It would not be possible under existing conditions—though the resources for it are within reach—to form such a collection as the Berlin Ethnological or Völker-kunde Museum, still less anything like the Imperial Institute, which by the way is being imitated by a syndicate of Berlin merchants; but this is a desirable direction in which to work, and with our Corporation as custodiers a beginning might be made in the benefits of which schools might, to a large extent, share.

If we turn to the natural sciences we have equally ample resources. There are in active operation among us the following societies, not to mention the all-embracing Philosophical Society itself:—the Andersonian Naturalists', Clydesdale Naturalists', Natural History, Zoological, Microscopical, and Geological. To these should be added the largely kindred Archæological Society. These are all organised bodies of scientific workers, and, if their labours were guided, though indirectly, into the channel of general education, should form the best auxiliaries in making public collections instructive to the young. And here I may conclude with a few practical, if not practicable, suggestions. A *catalogue raisonnée* of our collections, especially such of them as have a direct value for school instruction, ought to be accessible to every teacher, and even pupil, among us. Further, in these days of technical and commercial education, our local publishers might do worse than try a venture out of the ordinary line of helping School Boards to make money out of the public purse, and give us a handbook to our city with maps and illustrations,

containing not mere statistics, or a series of trade circulars, but giving an instructive account of our industries, their localities and nature, the objects, sources, and destination of our commerce, food and water supply, cleansing and lighting, municipal government and taxation, objects of interest, and the general environment of the citizen in health and disease. How few of the citizens know much about the city outside their own personal environment, such as the classic Molendinar, the old haunts and life of the makers of the city, the development of the Clyde and its industries, the *locale* of existing trades, and the conditions under which our world-wide commerce is carried on! In proof of how little in this direction has yet been done, who could, from a walk through the Kelvingrove Museum, guess the part played by Glasgow in opening up trade in South-eastern Africa, in the Plate valley, or in Burmah? Such a handbook as I have indicated ought to be familiar to all our children, for the town ought to be the source and centre of the townsman's mental development. Lastly, the council of this society might perhaps seriously consider the propriety of taking steps to form a commission or committee representative of the schools, the scientific societies, and the manufacturing and commercial organisations, that should co-operate with the Corporation in utilising and extending the resources of the city, so as to bring the rising generation into the closest contact with the realities, and not the mere text-books, of instruction.

In conclusion, there is no doubt that the atmosphere of objective or realistic teaching is around us. Science for the young has been tried as the ordinary work of book instruction, and the result can hardly be considered gratifying. For these and other reasons the present time is exceptionally favourable for considering such a development of the means of instruction as I have sketched. The Corporation, as the true custodian of the interests of the local body politic, is naturally suited to take it in hand. Glasgow is, besides, specially well fitted for the development of such a scheme, for it controls the Kelvingrove Museum, the Galleries, Parks, and Botanic Gardens. We are inclined to grudge Edinburgh the imperial sums spent upon her, but the situation is not without its compensations, and among these, not the least, that we have local control of such magnificent institutions for the diffusion of public instruction—a species of Home Rule that appeals to politicians of every shade.

VIII.—*On the Training of Architectural Students.* By FRANCIS
H. NEWBERRY, Head Master, Glasgow School of Art.

[Read before the Architectural Section, 28th November, 1887.]

"DRAWING may be taught by tutors, but design only by Heaven." So says John Ruskin, a writer whose thoughts I shall have occasion more than once to call to my assistance; but, like other phrases coined by that aphorist in art, the sophistry of its meaning separates human execution too widely from human ambition—what we do from what we desire; and I would suggest that the sentence would read much better if it had, in addition, the wholesome and cheering proverb, "Heaven helps them that help themselves." Genius or inspiration, when its existence is proved as belonging to any one man or work, may or may not be a Heaven-sent gift; but, believe me, study and practice go much further than is commonly supposed towards developing the latent powers of a man, else would genius knock in vain for admission, or, if the door be opened, be greeted as a stranger.

How best, then, to cultivate the powers that belong to any ordinarily-endowed architectural student, so that he may, if not excel his fellows, take at least a position which may have the credit of a respectable mediocrity, and, leaving genius out of the question, educate him so that he may know what he has to do and do it, is my object to show.

There comes a point in the education of every earnest man when teaching, as such, becomes practically useless, and guidance even may be at fault. Up to that point I would go, and, patent to the subject of this paper, would venture to indicate how, to me, the artist in the architect may be developed, leaving to others the task of dealing with the technical workman and knowledge of an architect's business.

This division I make empirical. Architecture is a fine art whose appeal to ourselves is made through the medium of building. "To build is, by common understanding, to put together

and adjust the several pieces of any edifice or receptacle of a considerable size, and building does not become architecture merely by the stability of what it erects. Architecture is the art which so disposes and adorns the edifices raised by man, for whatsoever uses, that the sight of them contributes to his mental health, power, and pleasure." Ruskin here makes a sharp division between building, as such, and architecture, which may be co-existent with it, and adds a corollary, if, as goes in the saying, the architect be the artist, then in common with him he is divisible so to speak into two men—the designer whose brain conceives and the workman whose hands execute. With the first man we have to do.

Now, let us take the education usually afforded to an architectural student outside the educative influence of his master's office. (1.) A course of building construction of the book order, generally and chiefly given less with a view to the cultivation of a knowledge in the student than with the object of filling him with a superficiality which shall enable him to pass certain examinations. In it he digs foundations with imaginary spades to unknown depths, piles ethereal brick on brick till his shadowy walls eclipse Babel's fabled height, covers this with a roof as vague as the empyrean blue, and having completed an edifice whose inhabitants would find their chief safety to lie in the living outside rather than inside its sheltering walls, the student sits down wonderstruck with the result of his efforts and in the possession of—a certificate.

He is then in a position to pass on to (2) a study of the orders, likewise learnt from paper. By these means he gathers the information that the Greeks were eminently a mathematical race; that their edifices were composed chiefly of compasses and set squares; that they put 2 on 3 and 5 became a thing of unutterable beauty; and the Parthenon, which he may perchance be dogmatically informed was a temple of exquisite proportions, appeals to him as a huge arithmetical sum whose decorations consisted chiefly of entablatures, modules, triglyphs, and diameters. He next passes on to the third and final stage, whereby his education is to be thoroughly completed—namely, design. This is too vast a field of opportunities to him, for me to safely follow. It usually commences with a cathedral and ends with his waking up to the stern reality of every-day requirements

This description may be an exaggeration of the real faults,
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but the recognition of faults is half their amendment, and it will well serve its purpose if it show the fallacy of such a system of paper instruction. You will notice that in it nowhere is the artist considered. The workman everywhere predominates. Not an appeal to the principles of the past varies its monotony, or a ray of light from the spirit of the great works, which still cover our earth enlightens its darkness.

That an architect must learn construction must be conceded at the very issue, but whilst learning in the present how to construct a house for the future, he need not neglect the study of how buildings were constructed in the past; and the same treatment of his subject applies to every phase of his studies. The letter of the Greek must be obeyed before one can catch a breath of the spirit which animates a classic building, and the design which is to be must be developed from a knowledge and acceptance of what already exists. But this brings the student at once into a clearer light and into a field as vast as the world is old, a light which enables him to read and compare the lessons which past experience, as manifested in architectural structures, in ever inculcating, and a field which stirs the creative faculty in him to emulate, before endeavouring to surpass, that which the efforts of dead minds have created.

An art student should learn his lines by analogy, not by imagination, his proportions not by creation but by comparison, and his masses not by indication but by imitation, and he should become the artist not in spite of, but because of his education. Let the architectural student do the same and a like result should follow.

This last paragraph gives the three heads into which I would divide the education of the architect, namely, Line, Proportion, and Mass. I should state, however, that, for my own part, I fail to see the slightest reason why he should be treated differently from an ordinary art student; but as it is felt that he should always work in close alliance with his subject, I will accept such a view, if for no other reason than to prove that the artist can be got out of him as well by these as by any other means.

Coming, therefore, to

LINE,

visions of plans, elevations, sections, enlarged details, perspectives, &c., rise to view. Banish them at once. Their lines represent no more the ideas of an architect than do the words of a language

the thoughts of a poet. The lines I allude to lie in other places and on higher levels, and are not of necessity made by a pen. A certain chimney stalk of this city, we are informed, rises into the air as high as the spire of Strasburg Cathedral; yet who would turn for an instant from the contemplation of the living lines of that or any other cathedral spire to look upon the ruled contour of the highest chimney stalk the world possesses. The elliptical lines of the Parthenon fascinate us by their appeal to our sense of the beautiful, equally as the lines of a railway bridge over a river repel us by their incarnation of the ugly. Yet both are lines, and, to come to details, the segmental curve of a Roman moulding can never satisfy us as does the freehand sweep of a Greek ovolo or the flying line of a Gothic buttress.

How, then, is our student to obtain the power of drawing a line, and to cultivate the sense of beauty in line? Why, I should say, by not—as is usually the case—beginning at the wrong end, and accepting results without due regard to means. Let us take our student powerless to draw anything or to express a single idea by means of his pencil. What should he do first? Certainly not draw lines by means of a T square, nor obtain their measurements by the use of compasses. I know I strike here at the root of the system usually followed. But the architectural student has this in common with all other art students, namely, that his education, like theirs, should be of a kind that should develop two great innate qualities, namely, the power of the hand to draw a line, and the power of the eye to rightly compare or apportion its length. And yet he has to do this by drawing a line parallel to another line and by blinding his eyes with a foot rule! He is drawing plans and elevations—surely a part of his education? Granted; but we see objects seldom either in plan or elevation, but always as facts in perspective; rarely do we conventionally see them, but always naturally.

Take a common example, namely, a drawing in elevation of three or four flooring boards, supported on a joist as usually found in works on Building Construction. Now, you must have a design of this nature, to make what is called a working drawing; but as we do not, as a rule, exist with our heads wedged in between the joists of a floor, but with our feet standing upon the floor, it occurs to me that our student would receive a far more valuable accession of knowledge were he taught first to realise things as they are and as they really exist, rather than as they appear in the conventional

rendering of a workman's drawing. Let him therefore be taught to draw flooring boards as he sees them when walking across them every day, and then analyse their technical construction afterwards. But this entails a knowledge of perspective. Certainly. Why not? To realise facts and not experiences should ever be the aim of all art education, and a student should learn what is required of him by a necessity which is ever the mother of invention.

It were needless for me to multiply examples of this nature. They occur in a house, from the sleeper walls to the ridge-piece, from the footing to the chimney-pot, and I would submit that even only for the mere exigencies of time the student should rather be taught to make a freehand drawing which should realise this object, than a plan and elevation, which should give its mathematical measurements.

Let us then return to our student, whom we have left anxiously awaiting his fate at our hands, and tell him to put aside his compasses and T-square and learn how to draw, or, put more practically, to learn how to realise the facts of the appearance of any object placed before him, but in so doing never to forget that he is to be artist in the architect. No royal road lies here. He may be a Michael Angelo in embryo, for power of design, or a Palladio in similarity of adaptation, but, like them, he must learn that before he can design a dome he must be able to draw a dome, or to rightly impose an order, must train his eye to see the ordered beauties of proportion in an order.

It seems to me to matter little at first what the student is set to draw, but as in my premises I granted that he may be confined to his subject, let him draw from good examples of architectural ornament and work, common enough in all well-equipped schools or classes. Taking classic details at first, whose beauty, as that of all good work, consists in their simplicity, and passing on from these to Gothic where fancy broke through ordered rules and left the architect with a freer if not so learned a pencil, I would have him draw with pencil, pen, and sepia, from fillet to temple and from Gothic leaf to cathedral, not as studies merely to enable him to have a command over his pencil, but, under instruction, seeking out and comparing their hidden beauties and subtle boundaries, till he realise what is meant by the power of a line which is neither crooked nor straight, arched nor horizontal, and the beauty of a proportion untrammelled by rules and yet capable of the highest mathematical exactness. This may sound impractical,

and the question may be asked—Is the period which a student can devote to his education long enough for all this? I reply, yes; for all this and much more, for I am training my man; he will educate himself. All this need not be done at school or during any so-called period of education. To cultivate his powers of perception and selection, to heighten his sense of beauty, and to make him work, is all I want. The rest can safely be left to take care of itself. He will find out sooner or later by these means wherein his chief powers lie, and if his education end with his life, it will be because he realises its necessity. I would have no rule, or set of rules, even if such were possible, to make the student an architect, “but arouse his sympathy and stir up his imagination, and he may after that be neither feeble in life nor forgotten in death.” So says John Ruskin, helping heaven to realise the architect in the man. Of one thing we may be quite certain, that this proposed course of education will have made the student able to draw, and that being done, a part of the battle is won, and we shall have realised the first half of Mr. Ruskin’s aphorism, “Drawing may be taught by tutors.” We will try whether we cannot meet heaven half way on the second part.

Now, you can arm a soldier, but you cannot make him fight. You can, however, show him how; and the providing him with arms is an absolutely indispensable part of this latter proceeding. An architect unable to draw, not with mathematical instruments, which I do not consider the true architect’s properties, but with a pencil, is like a soldier starting to battle without the previous provision of offensive and defensive armour. Both are useless for real work.

I stated in my opening sentences that “there comes a point in the education of every earnest man when teaching, as such, becomes practically useless.” Naturally, I do not consider that point to be reached when a student has been taught simply how to draw. Instead, however, of walking before our student, our proper place is now at his side, I think, and having made sure of his hand and eye let us turn our attention to the training of his ideas; and this brings us naturally to the second of the three divisions I have employed, namely:—

PROPORTION.

I should vastly have preferred that the student gained his first rudiments of knowledge in this illimitable field by a study of the figure alone, but I choose rather to come point blank

to his subject, and put him through a course of what is generically known as the orders, and make him study the figure at the same time. This I do, for in Egyptian architecture the canon of proportion was based upon that of a conventional figure; in Greek we never can rightly dissociate Greek architecture from Greek sculpture; and only in Gothic do we have the proportions of architecture disconnected from a consideration of the human figure.

How, then, should proportion, under the generic term of the orders, be taught? Let us first find out how they are taught, and thus proceed from facts as they are usually received, and if the result be wrong, set ourselves to find out a remedy. The student usually commences with copying an extremely bad example of the Doric order from a flat copy; for be it here noted there does not exist to my knowledge any set of drawings outside books on the subject, that can fitly be said to be good representations of the orders. The drawing in question displays the Doric order dissociated from its place in the building, generally without the entablature, and represented as a couple of converging lines cut off at the top and bottom by horizontal lines, and possessing, as a rule, the added wrong and dishonour of having the middle part of the shaft bodily removed just where the entasis commences.

This maimed and disfigured picture he sets to work upon with compasses and T square, and, having made a copy of it, is supposed to have a knowledge of the Doric order. By equally easy treatments the Ionic and the Corinthian are added to his store with an equal accession of nonsense in the place of knowledge, and the student ends his course of the orders with a head full of disorders. He may possibly learn when treating these classic specimens in the manner just mentioned that the Doric was the finished excellence of Greek architecture or some other equally vague and misleading statement. That if this be the finish, where was the beginning, seems rarely to occur to him. It would seem to be tacitly assumed that Greece was one day without the Doric order, and the sun rose over that country the next to find it embellished with, and in full possession of, that surpassingly excellent specimen of human thought, execution, and taste. Now, this is not training the student, but trading on his gullibility. Does it ever occur to him that architecture was once without even the use of column; that roughly hewn and without any shapely quality at first, it became moulded upon by the thoughts of succeeding ages,

and shaped by the hands of generations of workmen, growing in beauty of contour, and in exquisiteness of proportion at each successive stage of development, until the snowy whiteness of the Parthenon displayed its subtle proportions and incomparable workmanship to a world which wonders yet only to lose, in the vast majority of cases, the principles there worked out in the beauty of the outcome?

I quote from Wornum a similar analogy in respect of our use of the Greek honeysuckle:—"The ornament is simple and beautiful, but modern imitators overlooking its principles have comprehended only the detail, assumed it to be an imitation, and have called it the honeysuckle ornament. Instead therefore of grasping the source of a thousand ornaments equally beautiful they have acquired but one, and half the classic buildings of modern times are covered with honeysuckles; bringing the whole art of Greece into disgrace for its monotony and formality, while there is scarcely a weed in England that might not with equal skill have been substituted for the honeysuckle with perhaps equal effect."

So is it with the orders. Recur to first principles logically, work them out, and a personal share in the glory of the result is ours. Instead of that our student grasps the ends, and loses sight of the means which brought them about. The work of the orders was not thus accomplished by the original designers. Genius must ever precede rules, not follow upon them. When a Greek would design, he piled mass upon mass, added line to line, cut contour from contour, touched necessity with the golden finger of invention, and left the result for other and later generations to come with note-book and foot-rule and mathematically demonstrate how it was all accomplished. The Greek as an artist perished, leaving behind him the monuments of his skill and genius, and the revival of a love of classic forms in the middle ages brought with it a host of workers in the note-book and foot-rule, who measured up and gravely calculated and came to the result that thus and thus the Greek did, and lo! the outcome.

Far be it from me to deprecate in the slightest the work of those glorious architects, foremost among whom comes the honoured name of Vitruvius, and later Palladio, whose efforts and learned treatises have made classic architecture our most precious heirloom, and whose exertions have made it possible for us here in the frozen North to realise by our productions the full

beauty of the ancient temples and edifices whose ruins yet stud the sunny land of Greece, although our eyes may never have gazed upon the originals. To them we here in Glasgow owe the fuel which fired the genius of a Thomson; but were he still in our midst, he, I think, would be the first to confess, that it was by no empty copying of dead details, but by a union of his thought with the thought of the Greek that his work was accomplished. And yet these details must be copied, but ever with the impression that the whole which is created by a synthesis of these details must ever be greater than the parts which analytically make up that whole, and that as all objects in Nature live because they obey great laws, so Greek architecture will last as long as the world, because of its fulfilment of the laws and principles of beauty.

This must be granted, and giving our student a note-book, I should at once start him to draw buildings. I would, however, provide him with a tape and foot rule afterwards—not while he is executing his drawing; and here comes in the good of his parallel and coincident course of figure drawing. For I would make it a rigid rule that the student drew first and measured afterwards, and in this to follow in a building the same course of treatment he would adopt in drawing an antique figure. Who dreams of appraising the proportions of a figure with anything but the power of the eye? And if so, why cannot a building be treated in the same manner? Because, it may be retorted, how can you obtain proper plans and elevations unless you measure each part accurately? Or how can you instil the power of mathematical exactness into a man who never uses the means? It is the last thing I would care to do. Should he desire, after having made a correct drawing, to verify it, and to test it, and to set it down as an architectural production, because such is usually required, his doing so does not affect my position; for should he find the two drawings do not agree, it is less because he finds his measurements right, than that his drawing was wrong, and a weakness in his work found out. Did not the beauty of the Doric or Corinthian orders exist before it was found out that these shafts consisted in the perpendicular aggregation of a certain number of diameters? And do the exquisite proportions of a Greek antique appeal to us with an added meaning because we are told it is seven and a-half heads high? But let us drive the matter straight home. An architect designing the proportions of

an edifice to be constructed, draws and re-draws until such proportions please his eye and satisfy its demands. It is the work of his assistant to convert this artistic production into the mechanical necessities of a trade drawing, and all I would ask is that our student finding out, instead of creating, proportions do adopt a similar course of treatment.

I need not detail further. Having pointed out how I think proportion can best be learnt, it matters not whether the student copies the orders in this manner from some good book, or elects rather to do them from buildings where their proportions have been adequately realised; or, better still, leaves them alone till a later period. Draw first, and measure afterwards. I state the principle, and he should again attack a fillet or a temple, a Gothic leaf or a cathedral, with similar equanimity, for, be it remembered, that the proportions of an object, be it a crocket on a spire, or a majestic cathedral, are best realised when, with every-day surroundings, they take their places in our common life and associations. The education of our student can never be complete without a course of figure-drawing from the antique and life, with its accompanying studies, anatomy, drapery, and figure composition. He will design best the proportions of what is lived in who best realises the form and proportions of him who inhabits, namely, man, the highest and most finished work of the great Architect.

The application of such knowledge leads to figure composition, and, by its aid, the lines of the stiffly-posed Minerva in the centre of a Greek pediment may to him equally have a meaning with the curved lines of the dying Greek and Trojan soldiers in the angles; and the headless Ilyssus or Belvidere Torso, or the fragmentary Theseus, all appeal to him as an embodiment of utility for architectural needs, combined with a beauty which excels those needs. Take, again, drapery. What study could be more beneficial to the student than this is for realising the power and beauty of line, whether as the exponent of past and present action of the figure which it clothes, as in Greek art where motion was sought to be illustrated, or as in Christian sculpture, where, copied from the thick and coarse stuffs of the monkish dresses, hanging plumb down and sweeping the ground heavily, it became the exponent of a gravity and repose which, physical in its treatment, had yet a spirituality in its meaning. All these studies have, in architecture, a mistress. To her the Greek gave the whole intellectuality of

which he was capable, and for her the Christian wrought out and put into stone his highest symbolism; and a single glance at the figures as usually carved for, and applied to, our buildings to-day must convince us that not in vain will our student have learnt the use and abuse of sculpture in architecture.

Line plus proportion gives

MASS,

the last of the three divisions I made, and I cannot do better than preface the treatment of this, the greatest of the three studies, by a quotation from the "Lamp of Power," one of the seven lamps of architecture as figuratively employed by Mr. Ruskin in his book under that name:—"And among the first habits that a young architect should learn is that of thinking in shadow, not looking at a design in its miserable liny skeleton, but conceiving it as it will be when the dawn lights it and the dusk leaves it; when its stones will be hot and its crannies cool; when lizards will bask in the one and the birds build in the other. Let him design with the sense of cold and heat upon him; let him cut out the shadows as men dig wells in unwatered plains; and lead along the lights as a founder does his hot metal; let him keep full command of both and see that he knows how they fall and where they fade. His paper lines and proportions are of no value; all he has to do must be done by spaces of light and darkness, and his business is to see that the one is broad and bold enough not to be swallowed up by twilight, and the other deep enough not to be dried like a shallow pool by the noon-day sun."

Now, an architect in his design has this to consider, more than any other class of designers, that he has to deal with length, breadth, and depth. A painter's information, while it should embrace an abstruse knowledge of the four sides of a human figure, with all their various positions and foreshortenings, can but express itself by a display of usually not more than two sides of the figure he is designing, while the building by an architect has to present itself four-square to all the winds of heaven. The closest analogy to his study of a building is met with in that of a sculptor's modelling of a figure, and this power of grasping mass can best be obtained by doing as does the sculptor, namely, by going through a course of modelling, and by these means to absolutely create a light and shade which may be all his own, as opposed to the imitation of a light and shade obtained by the execution of a drawing on a flat surface.

Architecture in this respect may roughly be divided into two sections, one in which the forms are drawn with light upon darkness, as in Greek sculpture and pillars, and the other in which they are drawn with darkness upon light, as in early Gothic foliage. This phase of an architect's education was, I remember, strongly insisted upon by Mr. J. P. Seddon in the criticism of some modelled designs submitted to him by a class of students in architecture, at the Lambeth Technical School. The subject was an Italian doorhead. After emphasising the need in architectural students in grasping the solidity, and not the superficiality of any subject, they may be set to design, he pointed out that the picture of the result should ever accompany the progress. And this should be so. Students should be taught to imagine a building not as bathed in the artificial light of an architectural sun which always casts its rays in angles of 45° from over the left shoulder, but to imagine their buildings as they are travelled across by the sun, and as having its own will upon their productions, and then to look at them again with the sun gone, and the skies grey and cold, and the rain pelting, or the snow falling, or the fog enwrapping their members, and to have pleasure in any of these imaginary aspects. "Architecture is the art which so disposes and adorns the edifices raised by man for whatsoever uses that the sight of them contributes to his mental health, power, and pleasure." So says Mr. Ruskin again, who, I believe, does not usually take either health, power, or pleasure, mental or otherwise, in walking the streets of any of our large cities, when the rain is falling, or the fog is descending. Venice, in the sun, is his ideal, the heaven of a light and shade which architects strive after, but are dogmatically told they may not attain to. Still, the attempt is worth the making, although we are positively assured by that author, if his dictum carry any weight, that the dead past burdens too heavily the young giant of the present for us ever to hope to cast him off. He may be likenessed as sitting in the tree bearing the golden fruit that approaches and recedes from the lips of Tantalus.

Here are some of his sentiments on Mass:—"What a contrast between the pitiful little pigeon-holes which stand for doors in the east front of Salisbury, looking like entrances to a beehive or a wasp's nest, and the soaring arches and kingly crowning of the gates of Abbeville, Rouen, or Rheims, or the rock-hewn piers of Chartres, or the dark and vaulted porches and writhed pillars of Verona. Of domestic architecture what need is there to speak?

How small, how cramped, how poor, how miserable in its petty neatness is our best; how beneath the mark of attack, and the level of contempt, that which is common with us. What a strange sense of formalised deformity, of shrivelled precision, of starved accuracy, of minute misanthropy have we, as we leave even the rude streets of Picardy for the market towns of Kent. Until that street architecture of ours is bettered, until we give it some size and boldness, until we give our windows recess and our walls thickness, I know not how we can blame our architects for their feebleness in more important work; their eyes are inured to narrowness and slightness. Can we expect them at a word to conceive and deal with breadth and solidity? They ought not to live in our cities: there is that in their miserable walls which bricks up to death man's imagination as surely as ever perished forsworn nun. An architect should live as little in cities as a painter. Send him to our hills, and let him study there what nature understands by a buttress, and what by a dome. There was something in the old power of architecture which it had from the recluse more than from the citizen. The buildings of which I have spoken with chief praise rose, indeed, out of the war of the piazza and above the fury of the populace: and heaven forbid that for such a cause we should ever have to lay a larger stone or rivet a firmer bar in our England! But we have other sources of power in the imagery of our iron coasts and azure hills; of power more pure nor less serene than that of the hermit spirit which once lighted with white lines of cloisters the glades of the Alpine pine, and raised into ordered spires the wild rocks of the Norman sea; which gave to the temple gate the depth and darkness of Elijah's Horeb cave, and lifted out of the populous city grey cliffs of lonely stone into the midst of sailing birds and silent air."

Out of this mountain of seeming exaggeration comes forth the mouse of truth, and the architectural student can, by adding to his store of mental knowledge the manipulative skill of modelling, approach closer to that heaven-sent and born genius, the artist who is, I fear, quietly assumed as being born educated, and therefore requiring none of the dull drudgery of the hard work that usually falls to the lot of less blest and badly endowed mortals.

What the student should model matters little. He may make the study a vehicle for knowledge of architectural ornament and figure, but it suffices to state that he obtain a power over the material so that he may roughly conceive a form and with it a

light and shade. He may perfect his studies as time and opportunity permit, and if he fail to grasp a cathedral front he may realise the play of light and shade in a boss.

With a knowledge of Line, Mass, and Proportion my treatment of the subject may fitly end, but I would venture on your patience by briefly touching upon very debatable ground, namely, whether or not a student whilst going through an academical course of instruction should design? I answer the question in the affirmative, but would qualify it by stating that the design should be entered upon not as an end to, but as a means of, knowledge, not objectively but subjectively. For I have found that work is ever the more heartily entered upon, and a greater good ensues, if the student have an end in view, as opposed to the desultory obtaining of information with a negative purpose. You will notice I have omitted all reference as to how the student is to obtain a knowledge of the various styles, which from Egyptian down to Victorian Gothic or Waterhousian Byzantine have claimed buildings as belonging to them, and I would submit that a knowledge of these various styles and their epochs may be obtained by the student designing buildings and construction in any and every particular style, so that he may interestedly obtain a knowledge of, and insight into, their several peculiar qualities, their relevant constructions, their respective uses, and their particular ornaments or ornamentation. The restoration of ancient temples, as done in many of our architectural schools, forms a very good illustration of the idea I propound, and the architectural student as subjective creator may well, by his adaptation of the exigencies of any given style, fitly precede and lead up to the architect conceiving an original building in a style. This is what I instanced very early in this paper as accepting the past for the sake of the future. The styles are mines whose treasures are endless; and when it is grasped that the builder of Glasgow Cathedral did not invent Gothic, it will be seen that a high degree of celebrity may accrue to the artist who works on the manner of his forefathers.

In reading the lives of the great dead artists one cannot help being struck with the vast amount of knowledge, practical and applicable, they possessed of subjects which we are prone to consider as lying outside the relevant education of an architect. Thus Giotto's frescoes adorn the edifices of a city, one of whose chief architectural beauties is the tower he designed. Raphael's

Pandolphini palace most beautifully realises our conception of architectural beauty and proportion, as do his frescoes fill us with the highest human conception of form. Brunelleschi, whose dome rivals Giotto's tower as the embellishment of the Cathedral at Florence, was a sculptor and a goldsmith. Leonardo da Vinci enumerates the making of designs of buildings for public or for private purposes and the executing works in sculpture as among his accomplishments, and professes in painting to do what can be done as well as any man, be he who he may; assertions richly proved by his works yet among us; and in Michael Angelo we have combined the greatest powers of painter, sculptor, and architect in one, as yet the possession of any single man that has lived among us.

If I would seem to go out of my way in adducing these facts, which may justly not appear patent to the subject of this paper, I have done so purposely to throw light on a side issue which, though not distinctly relevant to his training, may yet have a great power for good both upon him and it, namely, his reading. Striving to be cultured men so that they may fitly take the places in the social life of the world which their powers entitle them to, is not specially a quality which pertains only to architectural students, but a certain section of his spare time should be devoted to reading the lives of the great artists, so that his mind may be imbued by such means with their ideas and desires, while his pencil is busily employed with the practical study of their conceptions.

Napoleon is credited with the dictum, "Every soldier carries the bâton of a marshal in his knapsack." He, however, did not wait for the event, but worked for it. The drudgery of marching and counter-marching, and sleeping with the guns, had to be gone through, and gone through in earnest, before the bâton of the marshal was placed in his hands. But he knew its powers, and wielded them the better in the ordering of battalions and the placing of men. for that he had at one time carried the knapsack which figuratively held it. So the architect may command the dull stones of the earth to arrange themselves in ordered masses, and make beauty to live in undying splendour on our walls; may by his proportions lead the thoughts, and by his colours tinge the imagination, of worshippers in a temple, of the earth earthly, so that they may catch a spiritual glimpse of a building not made with hands, and all this by a knowledge and use of powers of the bâton he wields—a piece of pencil.

IX.—"*Greek Thomson*." By THOMAS GILDARD, Honorary Member of the Glasgow Architectural Association, and one of the Vice-Presidents of the Architectural Section of the Philosophical Society of Glasgow.

[Read before the Architectural Section, 30th January, 1888.]

At several periods in the history of the respective kingdoms of Scotland and England one style of architecture has been all but universal. At one time some particular variety of Gothic was generally accepted for almost all buildings, ecclesiastical or domestic; at another a certain modification of Italian prevailed, no less suitable for the purpose of the palace or the cathedral, as in the Whitehall of Jones, and the Saint Paul's of Wren. The volumes of the *Vitruvius Britannicus* show alike in public and private buildings how generally this style obtained during the reigns of Anne and the earlier Georges.

It would be curious to inquire why the use of one of these two styles of architecture, so very dissimilar, was at one time so almost universally prevalent, and why at another time was the other; we know that, at least in the latter, there was over other arts and literature the same pervading genius—the same in the "*Spectator*" Essays, and in Somerset House.

When the poems and novels of Sir Walter Scott aroused a people that had been taking its ease in an elegant classicism, a wide and active interest at once was taken in everything mediæval—in Gothic architecture, the art of illumination, in heraldry, glass-staining, and blackletter book-printing. Britton, Coney, and others published plans, elevations, sections, and details of almost every old "pointed" structure in the empire; and Pugin and other enthusiasts, with an equal industry and ingenuity, showed the fitness of Gothic for every possible purpose. It became, principally in England, the reigning style, and so nearly did it monopolise the illustrations of the professional journals, that an occasional classical design was a surprise and a relief. Besides Sir Walter, however,

other authors were operating with new forces upon the old-fashioned British public, and classical architecture, if "scotch'd, not kill'd," to some degree accordingly reasserted itself. And perhaps, moreover, a comfort-loving people that had found sweet content about its head in the round soft contours of the Italian style did not take kindly to the sharp-pointed forms of the Gothic, or it may be that the sharp-pointed forms did not take kindly to a comfort-loving people; perhaps, also, some who were satisfied that Gothic was, of all styles, the most suitable for church buildings, did not find it that in which they could most enjoyably "take their ease in their inn." In a word, it was not easy to supplant by even the genius of a Pugin, the easy elegance to which we had been so long accustomed in a pre-eminently domestic style, which lent itself equally well to the designing of a palace for a prince, or a town-house for a merchant.

Sir Walter Scott having made the Gothic dry bones live, it is possible that the genius of Byron reflected anew the light that had shone from the glory of ancient Athens, that not only the poetry wafted to us from the Mediterranean, but also the personal engagement in the interest of Greek liberty, diffused around the "Antiquities" of Stuart and Revett a wider circle than that of the mere architectural student and classical virtuoso. With us thence may have issued, the situation so favouring it, the noble endeavour to accomplish for the Scottish Metropolis the title of the "Modern Athens." Thomson himself said of some early revivers of the supreme classicism, that, "unable to master the style, they became its slaves." Possibly it was deemed—

Too great, too good,

For human nature's daily food"—

well adapted for temples, as Gothic was for cathedrals, but too inflexibly severe to be readily bent to the purposes of commonplace domesticity, the city tenement, or the suburban lodging; and those who had neither reverence for pointed arches nor enthusiasm for level lintels, who felt no regard towards antiquity, either home or foreign, kept by the style that, transmitted from Wren and Jones and Chambers, had, in its almost universal adaptability, well served successive generations. Others, however, worshipping the rising sun, but not being dazzled by it, designed with clear, although somewhat limited, vision such legitimate and commanding works as the Edinburgh High School and the Royal Institution. Nevertheless, in the Greek there had not been discovered the plasticity

that was arrogated for Gothic, and which Italian under the reign of law certainly possessed; and so it was between the freer styles that a freedom-loving people had chiefly to choose when about to build for its nineteenth-century necessities. Then arose what has been called "the battle of the styles," and which, on both sides, was waged with great skill and vigour. Perhaps nothing more inclined the classicists towards victory than the surprising appearance of the Reform and the Travellers' Club-houses by Barry. These, if they showed little invention, displayed such a happy composition of old features, such admirable massing and proportion, and such purity of detail, that they gave to Italian architecture, if not a new life, at least a prolonged one of general regard for elegance and dignity.

It was about the time that this battle was fiercest that Thomson began business. He gave no allegiance to either side, but seemingly of set purpose devoted himself to the problem of throwing the grace and grandeur of Greek genius over the many and complex building-wants of a people much more practical than impressionable. The possibilities of the style were as yet undiscovered; even as a "limited liability" Greek was not generally understood, and consequently it was not generally appreciated; notwithstanding the Byronic associations and the Edinburgh experiments, it enjoyed not the *vox populi*; it was tolerated by the dilettanti, and ridiculed by the ignorant. Thomson's genius may be said to have re-created the style—not, however, as it was possible in ancient Greece, because in the times of Pericles and Alcibiades there were no circumstances that could give it opportunity. Where there were no buildings of many windows there could not be a many-windows architecture; and when, in our own country, buildings of many windows became of commercial or other social life a necessity, with these, perhaps, no style of architecture could have less sympathy than the Greek. Thomson's Greek, however, was new, such as was unknown in an age and country that had no tenements or warehouses; nevertheless, it is in the most perfect harmony with the spirit, if not the letter, of the monuments of the Acropolis. Mr. Roger Smith, speaking at the Society of Arts, London, said—"There is one living architect of genius, Mr. Alexander Thomson, who, by his works, is at the present day showing that Greek art, properly used, can be applied with success to the buildings required for ordinary use in Glasgow."

Mr. Smith spoke of Thomson as an "architect of genius." It has been said, however, that a work of genius must be upon a scale of magnitude, must be universally recognised, and must be of materials that ensure a perpetual duration, and that in Thomson's works there are none of these constituents. This was said to me by a friend when I was speaking to him of the preparation of this paper.

In works of genius material bulk is not necessarily an element. Between material and mental greatness there is an admitted difference. The Roman Colosseum is one of the largest buildings in the world, but, in Thomson's own words, "the Colosseum is bad in form, and treated with a degree of rudeness that corresponds well with the unhallowed purpose for which it was built." The Greek circular temple, commonly called the "Lantern of Demosthenes," is in material bulk of very little consideration, but in artistic skill it is of the very highest value. Indeed, it is a characteristic of the great Greek works—works the genius in which is wholly beyond question—that materially they are comparatively small; the Parthenon of Athens, for instance, as compared with the Colosseum of Rome. There may be more artistic genius in a Greek vase than in a Trajan's column.

Nor is it necessary that to claim for it genius a work must be universally recognised. In that admirable criticism which Shakespeare puts into the mouth of Hamlet, he makes the Prince say there is that which "though it may make the unskilful laugh, yet cannot but make the judicious grieve—the censure of which *one* must, in your allowance, outweigh a *whole* theatre of others;" and he causes the hero of Agincourt to say to the daughter of King Charles of France, "We are the makers of manners, Kate." Of nothing is the British public more ignorant than of architecture and sculpture as fine arts. It is probable that a thousand admire the figures in Mrs. Jarley's waxwork for a hundred that can appreciate the sculptured friezes of the Parthenon. There may be genius without any recognition—"Some mute inglorious Milton here may rest." How many works of genius are known only to the few, to the learned, those only who have access to them, and who, from their culture, are capable of judging.

Nor is it a requisite of works of genius that they be of imperishable materials. The Barberini vase is broken, even the great temples of Egypt are in ruins. There are works of genius which perish in the using. No one will deny genius to Garrick and

Kemble, nevertheless its material representation—the gesture, the tone, the facial expression—has passed away. The genius of Turner was conspicuous in his colour, "the light that never was on sea or shore," but

"The treach'rous colours the fair art betray,
And all the bright creation fades away."

How few of the works of genius comprise the several elements of greatness of size, universal recognition, and ever-enduring materials. "*Tam o' Shanter*" is a poem the excellence of which is by everyone acknowledged; but it is of no great extent, and its duration is imperilled by its being in a language that is becoming obsolete. The Venus of Milo is not a large statue, its excellence is known almost only to artists and art-critics, and the material by which it is expressed is certainly not imperishable. The beauty of the Parthenon is, or at least ought to be, very generally admitted, yet materially this building is neither large nor lasting. Of great architectural works, there are few, I fear, that comply with the conditions enunciated by my friend. Doubtless there are the Pyramids.

We must take Thomson's genius as we find it, and that is chiefly in having re-created a style—re-created it as water exhaled from the pure clear lake returns to the earth, refreshing it as dew. This style is homogeneous, not here a little and there a little, but is within itself complete. A cultured architect visiting Glasgow sees from a distance some building of original composition, yet exquisite proportion, and hastes towards it that he may examine its details. He finds that these are of the aptest congruence with the general design—as if an arboriculturist, seeing from a distance some unusual tree, uncommon in its massing, grouping, and general configuration, found when he came to it, that its bark, its leaves, its flowers, its fruit could belong only to itself, and that they naturally arose from the very disposition that gave to this particular tree its specialty of outline. In this re-creation there is as much genius exercised as in the original devising. Shakespeare, in re-creating the story of the conspiracy against Julius Cæsar—fitting it for an Elizabethan audience—showed perhaps more genius, so "bettering the instruction," than did Plutarch, from whose "*Lives*" he derived the information. Thomson imposed upon himself the task of carrying the spirit of Greek art from the temple-crowned Athens to the warehouse-thronged Glasgow; and, notwithstanding that the Greek remains are comparatively

few, so conjuring with them that, had it been possible for our nineteenth-century architectural necessities to have been the architectural necessities of Greece in the time of Pericles, they would have been to the old Athenians as they are to us by Thomson. As I have said elsewhere,* "His genius seemed to be less derived from than native to Greece, as if it had breathed its air, and joyed in its sunshine—developing under Helios, rather than 'pushing' in a conservatory—less educated by Stuart and Revett than impelled from such circumstances as gave colour and character to the Athenic life when at its fullest."

As Greek art is the most perfect, so is it the most difficult; it is "the entire and perfect chrysolite," from which, without injury, nothing can be taken, and to which nothing can be added. As is said in a recent work,† "it was not a partial or one-sided development that was aimed at by the Greeks, it was harmonious and complete—that of every part in due proportion. Among people regulated by such instincts and principles—insisting upon unity wherever and just so far as there was sufficient homogeneity in the constituent parts to admit of it, and upon the strictest symmetry among those—a building could no longer remain a congeries of independent members; it would become, in the amplest sense of the term, a work of art." To reduce an art such as this to the alike complex and commonplace wants of our time and country was beset by many and varied difficulties. To satisfactorily combine the Greek integrity of art with the varied wants of business required in invention and in judgment the powers of no ordinary genius. It has been done, and we are familiar with it. "Custom hath made it in us a property of easiness." A new style of elevation for otherwise ordinary tenements, as in Eglinton Street, does not now surprise. It has been copied, and its success has stimulated towards the attempting of those styles *that do*. In Thomson's business lifetime there was among the cultured of the profession something of curiosity to know what was his latest invention, some degree of eagerness to see the facile felicity with which he had modified the ornaments of Pallas to bedeck the robe of Britannia. They expected, and they were certain to find, something new and true—a sculptor's studio as sculptor's studio had never been before; a Pagan temple consecrated to Christian worship, of which it would be difficult to say whether it had less resemblance to the Pagan temples of old or to

* In *The British Architect*.

† "Culture in Helles."

the hitherto treatment for a similar purpose. He would have been a new man even among the old Greeks.

The studio which Mr. Thomson designed for his old and intimate friend, Mr. Mossman, was one of his first works that attracted the particular attention of other architects as art-critics. In quality of composition, if not also of detail, I do not know if, in any of his subsequent works, he has surpassed it. The site, the corner of two streets, one of which is level, the other having a considerable inclination, is taken advantage of with consummate skill as regards both artistic design and utility. Along the level street the walling is of cyclopean masonry, pierced by a doorway which, from its sill being on a level with the surface within, serves the purpose of "bank" loading, and on each side of it, by three openings, having broad dwarf pilasters between them, also on each side of the doorway, the extreme piers being of cyclopean work, part of the general walling. On the inclined street the composition is in four parts: the first, a continuation of the cyclopean wall, with its somewhat horizontal openings and their dwarf pilasters; the second, the gateway, with its piers "growing" from the general walling; the third, the screen between the gateway and the studio proper, with its doorway crowned by a block cornice and acroterion, and having a honeysuckle-and-lotus enrichment extending from each end of this cornice; and the fourth, the studio proper, composed of four pilasters and two extreme piers carrying a block pediment, between the pilasters a dado on a level with, and continuing the honeysuckle-and-lotus enrichment on each side of the door, the whole standing upon a cyclopean basement.

Another early work is the Caledonia Road United Presbyterian Church. In this building the portico fortunately faces the south, has considerable depth, stands upon a high and unpierced stylobate, except by a simply-dressed door at each extreme, and is flanked at one side by a lofty square tower, in which, on this southern elevation, there are no openings except in nearly the highest stage. The portico, comparatively small, is exquisitely proportioned, and, as the chief feature in the composition, it receives emphasising value from the solid character of the stylobate and from the lower part of tower. Nearly midway on the western face of tower is a boldly-designed window which, when the works of Thomson were few, I looked upon as the grandest individual architectural mere part that I had ever seen either on paper or in execution.

It is not a two-light window, but a one-light window divided into two by a pilaster with antæ supporting a cornice which serves as a transom. This pilaster, with antæ and cornice within a magnificent architrave, with frieze and a cornice supported by trusses, is characterised no less by great power and beauty than by novelty. On the east the storey standing on a high base of cyclopean masonry, and thereafter corresponding in height and treatment with the stylobate of portico, is relieved by only three great recesses like square niches, dressed with architrave, frieze, trusses, and cornice, similarly to the great window on the west side of the tower; and the upper storey is a continuous colonnade of square columns or pilasters. The site has a slightly acute angle; the church is a parallelogram in plan, and the remainder of the area—the side towards the west—is designed as a one-storey lecture-hall, the platform being at the narrow end so that all eyes may converge towards it. The church is lighted only by the windows in the continuous colonnade of the upper storey. The tower finishes square in plan; immediately above the three-light opening on each face there is in the highest stage, which is slightly stepped back, a circular panel for a clock, supported by characteristic scroll ornament, and the apex of the roof is surmounted by a plain two-armed cross. The portico is Ionic. I once asked Mr. Thomson why he had never used the Doric; he told me that he had never had a building whose size was worthy of it. The walling of the tower and of the stylobate is of that alternate high and low coursing—the low courses projecting slightly—so frequent, and applied with such marked and consistent effect in the works of Thomson.

In the larger and better known work, the United Presbyterian Church in Saint Vincent Street, the disposition of the parts is very similar, the Ionic portico resting on a massive stylobate with door at each end, and the tower, unpierced until at considerable height, flanking it. In the stylobate is a series of slightly horizontal windows separated by dwarf pilasters. On the return front, towards Pitt Street, which is on a very considerable inclination, there is a basement of large blocks irregularly jointed, having at its lower end a doorway of door and two windows. The elevation towards the lane is in some respects perhaps the grandest. The portico is in everywise the same as that towards Saint Vincent Street; it has the immense advantage of looking towards the south, and stands at a considerably greater height—the peculiar treatment of the stylobate, with its doors and windows, being of surpass-

ing power and dignity. Among the especial features of this church are, besides the stylobate, the magnificent walling and doorway of the basement in Pitt Street, the windows and dwarf pilasters in the stylobate towards Saint Vincent Street, and, of course, each portico, in itself one of those masterpieces that at once induce and require the most careful study. Over all there is the most exquisite detail, exquisite alike in its originality, in its intrinsic beauty, and in its adaptation. This placing of a tower alongside of a portico, retaining for each its individuality and yet uniting them so harmoniously, is so skilfully effected, that in the distance the painter is invited to prepare his canvas, and in the foreground the architect is challenged to the severest criticism; the one finding a picturesqueness of composition that ancient Athens never knew, the other a refinement of detail that it never surpassed.

From a certain point in Bothwell Street the general composition, and more especially that of the tower, caught upon the angle, the Saint Vincent Street Church must, for the classical student, when first he sees it, possess a singular fascination, this classic associated with picturesque in such unwonted yet aptest harmony. In moonlight, from the foot of Pitt Street, when, looking up to it on the hilltop, he sees, as it were in silhouette outline, the justness of its proportions; when at noonday from the South-side Park he sees it, as in a Turneresque picture, dominating a series of streets rising above streets like the rock-hewn steps of some Titanic staircase. What a mine of not merely new, but hitherto undreamt-of wealth, what a birth of inventiveness is discovered in this building, in the general design, and in the details alike of the mouldings and the ornament. In all this invention there is nothing importunate, nothing of self-consciousness; in this creation of a new system nothing of disturbance; all is composed and in repose, each is related to each, the dignity to the grace, and the beauty to the power: "It rejoices in, and is completed by law—strongly and sweetly from end to end."

Mr. Thomson once spoke to me of a possibility of the porticos of this church looking to the east and to the west. Both then would have had sunshine on them, and, as the site is the summit of a hill, each in being approached would have been looked up to from a considerable distance.

In Thomson, with the severe judgment and high culture of the Greek there was combined the rich and glowing imagination of the Oriental, and perhaps over none of his works has he so thrown

an oriental genius as over the United Presbyterian Church near to the South-side Park. I am not going to describe this unique building in detail. The originality of the conception, the felicity of the composition, the beauty of the detail are all characteristic of its author. I have always esteemed this church one of Mr. Thomson's most perfect works. It is singularly unfortunate in its situation—on a dead level, and almost circummured by ordinary tenements. Internally it is a surprise even to those not wholly unacquainted with the Thomsonic Greek. The preacher's platform or rostrum is in itself an education—unlike anything that remains to us from the ancients, and yet in the true spirit of Greek of the very highest. Other special features are the open roof, the choir-gallery behind the rostrum, the two tiers of gallery opposite, the artificial lighting by the candelabra on the platform and the jets along the cornice, and the polychromatic decoration. This decoration is rich and brilliant—it decorates surfaces, but in nowise disturbs an architecture that is independent of it. When it is said that it is from the pencil of Thomson himself, the severity, the delicacy, the power, the grace—in a word, the beauty and the appropriateness of the lines may be readily conjectured. In the colours, or rather in the harmonising of some of the tones, he had the assistance, frankly acknowledged, of the contractor, Mr. Cottier, now of London. The scheme of this decoration is as unique, as original, as is what is purely the architecture. Throughout the church there is not even one cubic inch of plaster, and the natural colour of the wood—yellow pine—contributes its tone towards the general harmony.

The Caledonia Road Church is also decorated from Mr. Thomson's designs, but for some reason, perhaps, more strictly speaking, no *reason*, the greater opportunity of decorating the Saint Vincent Street Church was denied to him.

I shall now look briefly at some of Thomson's works designed for other purposes. The great warehouse in Union Street is one that at once presents itself. As nowadays where are shops, there is "no visible means of support" to the superstructure, I need say little of the street storey, further than mention the ingenious manner in which the honeysuckle enrichment is run up the piers and carried along the lintel. Any praise or censure of mine can have little weight in estimating such a genius as Mr. Thomson's—

"Great wits sometimes may gloriously offend,
And rise to faults true critics do not mend,"

and it must be borne in mind how, with us at least, his works have elevated the standard of architectural criticism; yet I must say that the two storeys between the street and the uppermost seem weak, as having too much of an effeminate elegance, compared with the grand colonnade which they support. Perhaps the motive of the lowest of them may be found in the more ornate part being as a screen in front of the really supporting wall, for, looking from the pavement to the wallhead cornice, it will be seen that the general outline of the section is an ogival curve, the line bending inwards above this apparent screen, and again rolling outwards in the projection of the cornice. I have heard the wallhead characterised as the noblest in Europe, and so far as the professional journals and other means of affording information let us see, this high opinion cannot easily be gainsaid. One means by which this nobility is attained is the unbroken horizontality. How much more mean and petty would have been the effect had this cornice at any intervals been broken and interrupted. No man knew better than Thomson the value of the horizontal line, no man has more powerfully expressed it. It is a dominant element in all his compositions—in this magnificent cornice, as in a sketch for a book-cover. In these restless times of liberty—such liberty as of an escaped lunatic, with its styles and schools of an up-and-down, and an in-and-out, and otherwise knock-knee'd architecture—to the architect who would govern liberty by law, who would have his building an integer, and not an aggregate of fractions, the power of the unbroken horizontal line is one of the principal powers to which he should give respect and homage. Another notable quality in this entablature is its two proportions. It affects "a double debt to pay," "but yet a union in partition"—generally, a nice proportion to the height of the building, and within it, as it were, another entablature as nicely proportioned to the columns that carry it. When the uppermost storey of a building is one of the "orders," a question sometimes arises whether the entablature should be proportioned particularly to the diameter of the columns, or generally to the height of the building. If proportioned according to the order, it seems too light for the whole structure, and if to the whole structure, too heavy for the order. Whether it was by careful study, or by intuitive genius, Thomson has in the happiest manner, combining yet distinguishing, triumphed over what to many has been a difficulty, both speculative and practical.

The last work of this great architect—that at which he was working within two days of his death—was a design for a town-hall. The building, if I remember aright, was three storeys high. The uppermost was either the same as the uppermost of the Union Street warehouse, or was a slight modification of it; but the colonnade stood on a wall of banded ashlar, relieved only by three windows; and the effect of such a colonnade upon this high and almost solid wall, with its ever-recurring horizontal lines, was as if with the beauty of Greece was the stateliness of Egypt. In this, although small, subject, in working at which the pencil fell from his hand for ever, are to be seen the chief elements which Thomson always had before him—Order, Power, and Beauty. “Order is heaven’s first law,” and under its reign, subject to its inexorable rule, he expressed power and beauty, inspiring them with new life, and clothing them with fresh graces.

The Holmwood Villa, made familiar to us by Messrs. Blackie’s book, has deprived us of either asking or answering the question, Is an architect an artist? If architecture be poetry in stone-and-lime—a great temple an epic—this exquisite little gem, at once classic and picturesque, is as complete, self-contained, and polished as a sonnet. The connecting of the offices with the villa by the unbroken long line of possibly a garden wall, is an impressive instance of the value of a continuous horizontality. This value may be estimated by supposing the wall away, each building apart, solitary, and unsympathetic. By this supposition it will be seen that this mere wall is one of the most important parts of the composition. By the kindness of Mr. Bowie, I had an opportunity of seeing the interior. I need scarcely say that it was worthy of the remarkable picture I had been studying outside. Unique beauties and ingenious devices were to be seen everywhere. Of the polychromatic decoration of the walls, ceilings, doors, I might almost say “it beggar’d all description.” Mention is made in the “Spectator” of a lady who could not place a patch without spoiling a beauty, and to hang upon these walls a mirror or a picture would be not merely “a wasteful and ridiculous excess,” but a disturbing impertinence. Thomson’s idea was to make a room so perfect, so satisfying as a work of art, that it was independent of all adventitious means and appliances. “If you have pictures, have a picture gallery.” Besides the decoration, much of the furniture, solid and textile, was designed by Mr. Thomson.

Another building which we must look at is Great Western Terrace. You must stand far enough away to focus it in its entirety. The first thing you will likely notice is, that the one-storey-higher "lodgings" of the terrace are not, as is generally the case, the end ones; then in this all-embracing view your attention will be taken to the proportion of the height of the building to its length—the proportion of the higher lodgings, not only in themselves, but also in their relationship to the length and height of the terrace generally—their relation to it in their special position—and the intervals at which recur in the building throughout those stated features, the several door-pieces. Viewed thus as a whole, I think you have in this terrace as harmonious a work of architectural art as is permitted to be designed by a finite intelligence. It is upon its proportions and its relationship that it almost wholly depends, for so plain is it—"beauty unadorn'd"—that there is neither architrave nor jamb-moulding upon the windows; they are bare openings in the wall, but then most admirably proportioned not only in themselves, but to the solid spaces between them. Another thing, and one that gives a subtle charm to this building—something rather felt than seen—is that the walls have a slight inclination as has an Egyptian obelisk. Nevertheless, this grand terrace is not without anomalies. In the fenestration the solids are the uneven number, not the voids; the door-piece of the western three-storey portion is different from that of the eastern, and the eastern has in its centre, instead of an opening, a column. All this, however, is so overcome by the mastery of proportion that the windows have to be counted to prove the fact; and the fact that there is a column instead of an opening in a centre, may again, as it has done already, elude even frequent observation. After having once detected this anomaly, I never saw it again except when I was looking for it. Only a genius of a high order could with so few, and seemingly so simple, elements design a building of such composed dignity. The windows have no dressings, but Greek goddesses could afford to appear undressed.

" No meretricious graces to beguile,
No clustering ornaments to clog the pile;
From ostentation as from weakness free,
Majestic in its own simplicity."

Some others of Mr. Thomson's buildings I shall little more than mention. Of these are the stable, designed for Mr. Walker at

Hillhead—an admirable work, the highest art most happily bestowed on what by some might be deemed a mean object, were it not that of the greatest event in the world's history a stable was the birthplace; Westbourne Terrace at Kelvinside; a warehouse at the corner of Argyle and Dunlop Streets, now altered; Messrs. Blackie's premises in Stanhope Street; the little Terrace near Pollokshields, in which was his own house; a warehouse in Sauchiehall Street, in which may be seen the germ of the grand colonnade in Union Street; a warehouse in Gordon Street, in which may be seen a development from a building in Bath Street; Walmer Crescent, Paisley Road; villas at Langside; and many tenements of ordinary dwellings—ordinary, were it not that they show the same fine sense of proportion, the same care in detail, as do his buildings designed for even the highest purpose. In this we can look for, among other motives, a conscientious duty, the duty of doing not merely what is good enough, but what is best, the duty of throwing the joy of beauty over our every-day and most familiar surroundings. There are one or two alterations or additions which I would not willingly pass over, such as the great door-piece in Saint Vincent Place, for which, because of necessary changes, has lately been substituted the finely proportioned and detailed column-porch by Campbell Douglas & Sellars, and the front of Messrs. Frame's counting-house in Royal Bank Place, which, although apt to be overlooked in the hurried business walk, deserves, for at least some specialities, a careful regard.

Notice has been made of the colonnade in Union Street being developed from a building in Sauchiehall Street, and a warehouse in Gordon Street from a building in Bath Street. This modification of the same general design is to be found in other features of Thomson's buildings—for instance, the depending scroll on each side of the pilasters of the second storey of the Union Street warehouse is seen in wood in a shop front in Buchanan Street, and in iron on the warehouse at corner of Argyle and Dunlop Streets. There is also a peculiarity—difficult to describe—shown in both the Gordon and Bath Street buildings, a sort of growing from the walling of "detached" pilasters—the root, so to speak, of the pilasters being between the dressings of the windows which are seemingly imposed upon the general surface. It is not easy to account for an architect of such rare inventive powers reproducing the same idea, although varied in its details; it is not easy for *us*, but doubtless with *him* there was reasonableness and satisfaction. In Gordon Street a

menacing difficulty has been most ingeniously met and overcome. The series of windows beneath the pilasters, instead of being continued so as to embrace in it the walling beneath the two extreme pilasters at each end, is stayed, and for windows are substituted a sort of square niches, features of interest in their treatment, and contributing breadth and repose where there was an opportunity for weakness. This building was the property of Mr. Thomson and his brother, and it need scarcely be said that it would engage the usual care; nevertheless, since their deaths, presumptuous ignorance has endeavoured to "improve" it by adding a shop-cornice, a cornice that, with its trusses, &c., bears *prima facie* evidence to anyone that its relationship with the original design is that of the poor and the unwelcome. The building was designed without a shop-cornice, and why? For the simple reason that a shop-cornice was wholly foreign to the purpose of the architect.

We have seen that polychromatic decoration engaged the attention of this architect. It was part of his system—his scheme of a new Greek. His system was based upon principles, and he demonstrated that these principles were universally applicable. Hence, we see in the same style candelabra, vases, obelisks, and other monuments, cast-iron balustrading, furniture, &c. Some of these candelabra, such as we see in Union Street, and at the church at the South-side Park, possess great originality of design, a happy combination of strength of outline with delicacy, yet vigour of detail. The Union Street candelabrum is a tripod on a pedestal, the tripod and the pedestal each complete in itself and in its relationship to the other—"So with two seeming bodies but one heart." Of vases, there is the magnificent one in fire-clay, designed for the London Exhibition of 1851, and of which you may see copies in the windows of the Garnkirk Warehouse in Buchanan Street. It will command your immediate regard by its originality and power. The late George Mossman, in fine sympathy with the architect, enriched it with a sculptured procession.

Thomson's monuments are characterised by great breadth of treatment, dignity, and repose. There is one in Sighthill Cemetery, on the northern side of the great avenue, which is a rare example of what a monument ought to be—suggestive, solemn, integral, and yet not in its severity without the play of composition. An obelisk is an object of which it might be thought that the lines are fixed and unalterable. But even to the obelisk Thomson gave a fresh charm; where it was unimposing in size, he gave to it an interest

in beauty. One which he designed for the London Exhibition of 1862 derived much of its expression from the elegance of its entasis, independently of the ornament with which it was enriched. His cast-iron balustrading is, like all else that came from his pencil, distinguished by novelty, power, and grace. I may mention the balustrade in the staircase of Mr. Blackie's house, Great Western Terrace, the area railing in Saint Vincent Place, although now it wants its finials, and the railing as a panel in the gate of Holmwood Villa. It is the same with all the accessories to a fine art architecture. The rising generation is now familiar with trusses, friezes, capitals, &c., that to us older architects came as a glad surprise. I have been told that the varied designs by Mr. Thomson of the honeysuckle-and-lotus enrichment would of themselves make a considerable volume. He showed design even in the direction of a flame of gas.

It is obvious that whatever object on which Thomson was employed—large or small, a temple or a footstool—could be subjected to his own mode of treatment. Of the classic honeysuckle which he trained on the doors of warehouses and city dwellings, sprays were to be found on the desk or on the carpet. His system is comprehensive, all-embracing. It bears no evidence of any period of crudeness or immaturity, of a time of growing; it appears at once fully digested and in perfect vigour—as Athene sprang from the brain of Jupiter, of a full stature and completely armed. The Thomsonic style embraces, I think I may say, the conscientious use of the true elements of art—grouping, massing, light-and-shade, static equipoise, rhythm, relativity of parts to each other and to the whole, beauty and appropriateness of detail, the keenest sense of proportion, and the great power of repose, such repose as of the calm sea reflecting the calm firmament. He had with the rich inventive imagination the twin constituent of genius, the exact and all-governing judgment. Genius sees its own limits. If it has not paced all its perimeter, it knows at least its own diameter. Judgment deters it from seeking to look into the unknowable. If its range be within a garden of culture, it will not seek to overleap the walls that it may explore the briars and brambles of the wilderness beyond. If it does not, like Phæthon, set the world on fire, it is because judgment deters it from driving the chariot of the sun.

Those who have studied Mr. Thomson's works must have felt not only the appropriateness in character of the ornamentation,

but also the nicety of the degree with which it is proportioned to the general design. It is never obtrusively displayed and made "a feature" of; and, although of inviting interest, alike from its originality and beauty, it is less dwelt upon as an especial or individual part than felt as a pervading and gracious presence in the whole. Many of his surfaces are exceedingly rich; but the ornamentation is almost invariably in very low relief, or incised, never detracting from the breadth of the plane, or disturbing the outline of the moulding. His decoration is as proper to the design—as native to it—as is moss to the rosebud. It is eminently the right thing in the right place, designed not for the structure, far less upon it, but with it, and in it; and in a true architecture, where there is nothing to conceal, much less to disguise, fulfilling only its legitimate purpose—expression.

Some architects put their names on their buildings—Thomson's writes itself.

With all his rare ability, there was nevertheless one important thing which Mr. Thomson wanted—opportunity. As has been said, there is a difference between mental and material greatness, yet genius cannot be so well seen, at least it cannot be so much noticed, in a small building as in a large, in a building for a provincial purpose as in one of an imperial interest. Mr. Thomson, however, made designs for buildings of large dimensions and of national importance. The South Kensington Museum, had it been built from Mr. Thomson's designs, would have, to say the least, ranked high among the grandest Greek buildings in Europe; the design for the London Prince Albert Monument showed the colossal bulk with the sublimity of the Egyptian tempered by the subtle proportioning and the refining graces of the Greek.

It was wont to be the boast of the Gothic apologists that Gothic was the only style suited for a Christian church, and that in this style, "as broad and general as the casing air," there was freedom enough for endless variety, while in classic—"cabin'd, cribb'd, confin'd, bound in"—there was such restraint that design was restricted to commonplace conventionality and its wearisome repetitions. By Thomson's wide as well as high excursions in inventiveness, by the freshness of his freedom, by the rare dignity, and, it might be said, the sacred character that he has expressed upon his churches, the Gothic boast has been lowered in its tone, if indeed, like "patronage," as Carlyle says of Johnson's letter to Chesterfield, there has not been proclaimed of it that it should be

no more. Mr. Thomson had admiration for the genuine old Gothic work, although he had little sympathy with much of the new, and had he been spared, it was his intention to have visited several of the great English cathedrals, one of his objects being study for the continuation of his lectures. Of Thomson, as an art-critic, it is not within the purpose of this paper to speak; suffice it that "his precepts teach but what his works inspire." In his Haldane Academy lectures his pen is as fresh and as forcible as is his pencil on the Saint Vincent Street tower or the Union Street cornice.

I have incidentally given Mr. Roger Smith's estimate of Mr. Thomson's genius. The late Mr. Burges said at a meeting of the London Architectural Association—"Let me ask you to devote some time to the drawings of Mr. Thomson of Glasgow. They represent buildings in Greek architecture, but certainly the best modern Greek architecture it has ever been my lot to see;" and Mr. Moyr Smith, than whom few are more intimately acquainted with Greek art, wrote in *The Building News* in 1875—"If a man has the head-power he can use a style and adapt it to himself; if not, he adapts himself to the style. From materials supplied by a far less promising and far less tractable style than the English, Mr. Thomson of Glasgow was able to produce perfect specimens of civic and domestic architecture, which were at the same time perfect as specimens of advanced Greek, which is rather extraordinary, as everybody thought that Greek was perfected a couple of thousand years ago. Mr. Thomson's life and practice, it is true, were different from that of many of our architects. He was acquainted more or less with all styles, and selected Greek as the basis of his future work; he mastered the style, was thoroughly imbued with the Greek feeling, and gathering kindred riches from sources unknown to or overlooked by the later Greeks, the style advanced in flexibleness and fulness of design under his hands. His steady progress must have amply repaid him for the sacrifices he made, and the consciousness of reviving and carrying out a style till it reached the splendid culmination shown in the Union Street building and Saint Vincent Street Church, was, rightly considered, a reward greater than has been vouchsafed to any other architect of this century."

An appreciative criticism by a Mr. D. Thomson—not, I understand, the worthy member of this Society—appeared in *The Architect* of 19th November, 1886—"In the works of the late

Mr. Alexander Thomson, we have a fine series of designs of a character so unique and excellent as to excite our wonder at the fertility of his inventive faculties and our admiration at the beauty, richness, and vigour of his handling. In all of them he set himself to adapt the principles of Greek art to modern requirements, without any pedantic borrowing of their features. Indeed, it is quite surprising how seldom we find in his works the orders reproduced, with their details strictly conforming to the ancient remains. He more frequently originates some form of column and capital designed to meet the special requirements he had to deal with, or to conform to the character of the impression he wished the building to convey; but where he has used the orders they are appropriately placed, finely proportioned and detailed, with carefully-adjusted relief, the wall-space behind being kept subdued in tone, with no disturbing objects in it to mar the repose and quiet dignity of the design. The multiplicity and the variety of the details and forms he introduced into his works, and the singular grace and unity of effect he maintained throughout, are deserving of our most careful consideration, showing, as they do, that to adopt a style does not necessarily imply that only those marked features and peculiarities of detail and combinations which are found in the original works are to be reproduced, but that new forms and details may freely be employed, provided we have skill enough to maintain the spirit and essential qualities of the style. Of none of his designs can it be said that they are very like the old work, a term of praise we often hear applied to the works of our best men of mediæval proclivities; but, whilst they differ from the works of the Greeks as distinctly as the nature of our requirements do from theirs, they agree with them in the adaptation of forms to the purposes they subserve—the grouping of the parts into forms in which the horizontal lines predominate, the clear marking of the voids, the precision of the distribution, and the graceful adjustment of light and shade, with strength and placidity as a general expression. Only by the adoption of such principles as these can building be raised into a fine art. His churches in Saint Vincent Street and Caledonia Road, Glasgow, are in his best manner, while the various warehouses and other street buildings by his hand are all marked by the same elegance and refinement of detail, and display the abundance of his resources in design, and his power of impressing on them his own ideal perception of art."

**X.—*Early Sculpture in Scotland.* By ROBERT BRYDALL,
St. George's Art School, Glasgow.**

[Read before the Architectural Section, 13th February, 1888.]

IN the great unhewn blocks of stone still to be found standing in various parts of Scotland, sometimes singly, at other places in groups forming parts of circles, and more seldom in parallel rows, we see in the most remote antiquity the primitive intentions of the later sculptor's art. Theories hitherto have failed to account satisfactorily for the erection of these, but it is not unreasonable to suppose that, in many cases, single stones of this kind were placed to identify some spot remarkable for a victory gained or defeat experienced, or over the grave of a fallen hero whose actions were thus meant to be commemorated by his successors, whose stone implements were inadequate to do more than separate the monument from its quarry. As civilisation progressed, and tools of metal began to supersede the smaller ones of stone, efforts were made to enrich these stones with some kind of symbolic markings. What are supposed to be the earliest attempts are circular cup-shaped hollows irregularly sunk on the rough face of the stone, succeeded by incised designs of strange curvature, as circles within circles, suggestive of the tattoo forms of the natives of New Zealand, and other symbols more or less ornate, the meanings of which still baffle the research of the most ingenious investigator. So far back as traditional or written history goes, their purpose and meaning have been forgotten. The cairns, barrows, and other similar monuments, by their nature and contents, not only tell their intentions, but throw faint light on something of the habits and customs of the people who constructed them; the flat supported stones, sometimes encircled by others, such as the great Ring of Broidgar in Stennis, permit us to guess them as being places of assembly for judicial or other purposes; the runes on other monuments of a later period have been deciphered by the patient study of the archæologist, but the first rude attempts at carved symbolism are still as unreadable to us as a page of one of our books would have been to the primeval sculptor.

It has been supposed that some of the still remaining sculptured stones replaced the rude monoliths of an earlier date, probably before the causes of the erection of the latter were quite forgotten, and it has also with more reason been conjectured that some of these in their turn were replaced by early Christian monuments and crosses. On the same principle Christian churches were erected on Pagan sites, and heathen symbols were combined with those of Christianity. The earliest historical reference to the sculptured stones of Scotland occurs in the writings of Boece (who had a faculty for inventing stories), in which he says that King Reutha, about two hundred years B.C., "was the first king among the Scottis that fand ingyne to put nobill men for thair valzeant dedes in memory, and maid riche sepulturis for the bodies of thaim that war slane be Britonis in defence of this realme. He commandit als monie hie stanis to be set about the sepulture of every nobill man as was slain be him of Britonis. In memory heirof, sindry of thaim remanis yet in the hielandis, that the pepill may knaw sic men war vailzeant in thair dayis, throw quhilk it came in use that the sepulturis of nobill men was halden in gret reverence among the pepill. On thir sepulturis was ingravin imageris of dragonis, wolfis, and other beistis; for no inventioun of letteris was in thay dayis to put the deidis of nobill men in memore." The same writer in "The New Maneris and the Auld of Scottis," says—"They usit the ritis and maneris of the Egyptianis, fra quhome they tuk thair first beginning. In all thair secret besiness they usit not to writ with common letteris usit among other pepil, but erar with sifars and figuris of bestis maid in maner of letteris; sic as thair epithafis and superscriptioun abone thair sepulturis schawis: nochtheles this crafty maner of writing be quhat sleuth I can not say is perist; and yet they have certane letteris propir among thaimself quhilkis war sum time vulgar and commoun."

Antiquarian research has shown that while there are some characteristics common to all the sculptured stones and crosses of Ireland, Wales, the Isle of Man, &c., those of Scotland bear most strongly the impress of Irish art prior to the eleventh century. They also give evidence of a more intimate intercourse and community of customs between the natives of Scotland and Ireland than obtained between those of the northern and southern parts of Great Britain; and, in addition, they cannot safely be ascribed to Danish or Norwegian settlers. Many of the crosses on the Isle of Man closely resemble the Scotch, as, indeed, do some of

the early stone carvings of other countries; but in none of the Danish stones in Man or Scandinavia do the symbols so frequent on the Scottish pillars appear. Runic inscriptions on some of those in Man not only tell the purpose of their erection, but also bear the Scandinavian names of the persons concerned. Thus " * * * this to his father Ufeig, but Gaut Bjornson made it," appears on one; on another, "Oter erected this cross to Froga his father, but Thörbiörn son of * * *" was probably followed by the name of Thörbiörn's father, and the words "made it." Regarding these, Mr. Worsæ says that one sees "every reason to conclude that the splendid specimens in Man were carved by Norwegians, who, though they imitated the monuments in vogue in Scotland, frequently allowed their own characteristically fanciful ideas to display themselves in peculiar devices."

In Adamnan's life of Columba, instances are given of the occasion of the erection of two of the once numerous crosses in Iona. It is related of Ernan, the friend of the saint, that, on being seized by a fatal illness, he desired to be carried to Columba; before his wish, however, was fulfilled, that he should die beside his friend, he expired near to the gate Canabae, in front of which a cross was erected to commemorate the event. The other instance refers to the erection of a cross on the wayside, at a spot where Columba rested on returning from blessing a barn, shortly before his death. In further illustration of the same, it is chronicled as having been the custom of St. Kentigern to erect a cross at any place where he had made converts; a large one was thus erected at Glasgow, and another at Borthwick. When St. Cuthbert withdrew from the Monastery of Dull, in Athole, his first work was to erect a great stone cross at his mountain retreat on Doilweme; and in Ireland, in corroboration of what has already been said, the custom is mentioned of St. Patrick having consecrated the existing heathen stone pillars to Christian uses, which were followed by the erection of crosses in their stead.

Among the devices which appear on the rude pillars, oblong slabs, and in some cases on erect cruciform stones, one of the most common is what is known as the "spectacle" ornament, formed by two circles, sometimes enclosing others more or less complicated, connected by a bar of horizontal or curved lines, and occasionally traversed by the "sceptre," as it is called, in the form of the letter Z reversed, its extremities being variously foliated. Among other symbols are serpents; single and double crescents variously

arranged, sometimes in combination with varied forms of the sceptre; mirrors, frequently accompanied by combs (supposed to indicate the grave of a virgin); horse-shoe and torque-shaped figures, fishes, walrus, and elephantine-looking animals, often enriched with interlaced work, and numerous other figures of a more intelligible meaning, such as hammers and anvils and tongs. In support of the assumption that these now unintelligible forms had a definite meaning, it has to be noted that, while similar figures continually occur on different stones, the arrangement continually varies, as well as the filling in with other lines and details. In some cases the sceptre is found twice or thrice repeated on the same stone, and in each case with a slight change of form.

With regard to some of these symbols, they are by no means confined to sculptured stones. Thus, the "spectacle" and "sceptre," with a scrolled animal's head, appears on an oval-shaped silver plate of about three inches in length, forming a portion of what is known as the silver armour of Norrie's Law. A corresponding circle, similarly divided to one of the usual forms on the spectacle, is carved on a piece of ash wood about five inches square, which was found along with a canoe and paddle in a crannog at Loch Lee. The use of either of these objects is unknown. It is sufficiently intelligible that an emblem of the occupation or character of the deceased should be engraven on the stone marking his final resting place. That a sword might appropriately mark the grave of a celebrated swordsman or serve as an emblem of his rank; an armed figure that of a warrior renowned for his prowess; or a hunt that of a famous hunter, is clear enough; but the continual recurrence of similar combinations of mere lines, circles, and tolerably skilful carvings of animals of known species, all point to the existence of a language of symbols, the key to which is yet to be discovered.

At what is probably a later date than the first use of these devices, figures often occur—robed priests, sometimes with peaked beards, armed figures on horseback or shooting with bows and arrows, others seated as if in judgment, in procession with oxen, or being devoured by animals, with an innumerable variety of grotesque monsters, many of the animals being then unknown in Scotland, and the representations of which bear evidence that the artist was reproducing a traditional form which he had never seen in reality. Whilst there is in these early efforts a total absence of the delicacy and elegance which are observable in the southern

sculptor's art of the same period, and which was nurtured under Byzantine influence, they are extremely interesting as a reflection of the character of a semi-barbarous people, besides being full of a rich fancy, finding its expression in the representations of struggles between man and the lower animals as if contending for the right of living and possession of the land. Here and there we find groups which may safely be associated with the labours of the early missionaries of the Christian religion; thus, a repeatedly-occurring representation of a figure standing or sitting between leonine animals points unmistakably to the story of Daniel in the den of lions—a story which would appeal strongly to the feelings of a semi-civilised people, and serve the early missionaries as a striking illustration of Divine protection under circumstances of extreme personal danger.

The interlaced work so common on old stone crosses and sepulchral slabs (which had its prototype and probable origin in early Irish work, continued long afterwards, and still perpetuated in Highland ornamentation), gradually came to be associated in some districts with a Norman character, presumably from the taste and skill of some of those adventurers who found their way northwards in the eleventh century, soon after the Norman Conquest of England. Crosses and other stone carvings are frequently to be met with bearing this changed character, and a very notable example of the mixture of Celtic and Norman sculpture occurs on the beautiful and interesting little twelfth-century church of Dalmeny. In this fine specimen of old architecture, while Norman sculptors may possibly have been employed, the native Celtic art is perpetuated, especially on the flat inner moulding on the main entrance doorway, on which, as well as in the intervals between the projecting heads on the outer moulding, appear the hippocampus and other curious animals so often occurring on Celtic stones, these being probably by local carvers, and meant to preserve Celtic symbolism and tradition. The absence of Saxon influence on early Scottish sculpture is at the same time worthy of notice. Traces and remains of Saxon sculpture are extremely rare in Scotland, and confined exclusively to the more southern counties, such as Dumfriesshire, where an interesting specimen in the form of the shaft of a Saxon cross was discovered in Hoddam Church in 1815.

Probably the earliest specimens of ecclesiastical sculpture which we possess are those on the Celtic tower at Brechin. Rude and

small (some twenty inches or so in height), they consist of a crucifixion in the position which the keystone would occupy on a larger arch, the figure of an ecclesiastic on the jambs at each side, and two crouching animals of a Celtic character. The date of the tower is somewhat uncertain; some authorities claim it as a work of the eighth century, but perhaps it would be safer to assume it as having been built two or three hundred years later, contemporaneously with the commencement of the church to which it is attached. In any case the work must be put down to a very remote antiquity, certainly prior to the thirteenth century. The crucified figure is not cross-legged, the crossing of the limbs seemingly not having been adopted in such representations prior to the early part of the fourteenth century. A similar doorway, but more rudely executed, appears on the tower of Donoughmore in Ireland, on which, however, there are only heads on the jambs. Among other work of that far back period, not now existing, I may mention a little church at Abernethy, of probably the eighth century, on which the nine virgins and the miracles of Dovenald are said to have been sculptured.

In the twelfth century David the First, in the foundation of bishoprics, and the building and endowment of numerous monasteries at the expense of grants of land out of his patrimony, must have been the means of producing many pieces of sculpture; but in the splendid edifices which he is said to have originated, hardly any vestiges remain of sculptured figures, and these are of the least important kind. There is absolutely nothing of this class at Kelso or Jedburgh. A stone font decorated with coiled dragons, and one or two insignificant fragments of the period remain at Dryburgh. At Melrose a few decorated mouldings, small figures, and a Madonna and Child, much broken but of great elegance, no doubt owe their preservation to the almost inaccessible positions which they occupy; but even these must be assigned to a much later date. There is a close resemblance between the Madonna and similar French work of the period, especially that on Rheims Cathedral, suggestive of the idea that it is of French workmanship.

From David's time, the old Celtic art lost its sway, to be succeeded by the Norman or ecclesiastic. The cry for reformation seems to have been uttered then as well as now, although not so loudly. The brotherhoods of St. Serf and the Culdees were superseded by monasteries. New relations began to take form

in different parts of the country, by which the comparatively uncivilised north and west continued to remain isolated, while the southern parts of the kingdom became more important as places of strength for defending the country from English incursions. Thus the Lothians and the more southerly debateable lands gradually became consolidated into the kingdom of Scotland. However rapidly these changes may have been effected, they did not all at once affect the art; and in the northern parts of the kingdom there still exist numerous specimens of a high order, many of which are of a later date than that of King David. Sepulchral figures in the style and costume of this period are exceedingly frequent, but many of them are of comparatively recent execution, as the later highland chief seems to have had a fondness for appearing in his effigy in the character of a Norman knight. In the outlying districts of Argyleshire and other northern localities, the gradual transition of the art can best be studied in such scattered vestiges, and the teaching of the Christian religion as a message of peace becomes manifest on tombs of ancient warriors. The figures of helmeted knights grasping spears are to be found alongside those of saints and ecclesiastics, and others of a later date are shown in the act of returning their swords to their sheaths, their battles being over and a life of rest about to begin—different from the old Norse ideas of daily fights and nightly carouses. These, again, were succeeded by others, on which, under a more matured form of Christianity, the sword is left undisturbed in its scabbard, the head clad only in the bassinet and camail, resting on helm or cushion, the eyes closed, and the hands pressed together in prayerful action, with a lion or other animal writhing under the armed heel.

The thirteenth and fourteenth centuries were times of such trouble and strife in Scotland that one would not expect to find much appreciation of art in any form existing; but in spite of this, and poor as the country is sometimes represented to have been, there is abundant evidence to prove that at least a love of magnificence was often possessed by its nobles. Among other instances which might be referred to is that of the great hall of Randolph Murray's castle of Tarnaway, the ceiling of which was carved and decorated, and such tombs as those of the Douglasses, which still retain fragments of the original painting and gilding, not only on the figures but also on the escutcheons on the walls. Neither must it be forgotten that in the Treasurer's accounts of

the period there appear such native names as Thomas of Strath-earn, Friar Thomas Lorimer, and John of Aberdeen, in connection with artistic work of other kinds; also, when there were Scottish natives found, as seems to have been the case, capable of executing such seals as those of Robert the Second, it may reasonably be admitted that Scottish artists may often have been employed in the production of sculpture.

Of the now lost specimens of the art of monumental sculpture reference may be made to the tomb of Mary de Couci, the second wife of Alexander the Second, who was buried in Newbattle Abbey. Regarding this Father Hay writes, "in the midst of the church was seen her tomb of marble, supported by six lions of marble, and a human figure reclining on the tomb, surrounded by an iron railing." Barbour, in his history of the Bruce, tells us how, when the great monarch died, he was "solemply erdyt in a fayre tumb, in till the quer" of Dunfermline Abbey. The carefully-kept Exchequer Rolls of the period record the fact that the tomb was executed in Paris by a Richard Barber, from whence it was sent *via* Bruges, at the cost of £13 6s. 8d. (modern money) — a further disbursement being made in the same year, 1329, to "Johanni de Lithcu [Linlithgow] pro expensis faciendis circa sepulturam regis." The tomb was erected in the August following the June in which the king died, from which short interval it may be inferred that he had it in preparation, anticipating the near approach of his death. Some fragments, believed to have been a portion of the tomb, were unearthed on the discovery of the body in 1817-1818, which are described as being "elegantly chiselled into different small compartments resembling Gothic arches, the ornamental parts being gilded."

It is interesting, as well as curious, regarding David the Second, who introduced some Italian art workmen into this country, that tradition formerly indicated him as having handled the sculptor's chisel to pass away some of the weary hours during his captivity in England. Speed, who was living in 1611, describes a vault under Nottingham Castle which was remarkable in his time for having our Lord's passion cut on its walls, the work, it was then said, of the royal captive. The second Robert, whose reign links the fourteenth with the fifteenth century, like his great ancestor, gave instructions for the preparation of his monumental tomb during his lifetime; and the fact is recorded that the monument, which was in the first instance brought from England by sea, was

sculptured by Nicholas Haen, the king's mason, and further decorated at Holyrood by Andrew the painter. It was afterwards conveyed by water from Leith to Perth, and deposited in the church of St. John, where it remained till required for the interment at Scone.

The very close relations existing so long between Scotland and France, as well as the patronage bestowed upon artists by James the Third and James the Fourth, tended largely to the cultivation of taste in Scotland, although some of the followers of the first of these kings did not permit their taste for art to hinder them from hanging Cochran over the parapet of London Bridge. It may be accepted as certain that sculptors and sculpture were imported from abroad, as was the case with painters and pictures. On the other hand, there is an instance of two Scotchmen having been employed by the Duke of Burgundy, as painters and carvers of images in the fifteenth century. The curious Ledger of Andrew Haliburton, a Scottish merchant located at Middleburg from 1493 till 1504, and who held the office of Conservator of the Privileges of the Scottish Nation in the Netherlands (consul, as we would now define him), gives evidence of some such importations. Mention is therein made of John of Pennicuik having imported an image of St. Thomas à Beckett bought from a painter in Antwerp, and entries also occur of the shipment of tombstones from Middleburg to Scotland.

Of about the same date, some details are preserved of the construction of the tomb of James the Third, the Treasurer's accounts of which illustrate the scope of work practised by the artist of that period. Under date 15th March, 1501-2, appears the item of fourteen shillings "to David Prat and the masounis that hewis the lair in Cambuskennethe, of drinksilver;" on the 12th June following a further payment is "giffen" to the same "quhen he began the laying of the lair;" to "David Prat and the masounis that workis laying of the lair;" "to David Prat to buy colouris to the kingis lair;" "to David Prat payntour in part of payment for the making of the kingis sepeltur;" on 5th July, 1508, eighteen shillings "to the Almanye [Fleming or German] that suld mak the kingis lair in Cambuskennethe in marbile;" and a last payment on the 7th July "to the Abbot of Tungland to gif the man that suld mak the kingis lair." This extract is one of many which might be made illustrative of the variety of work executed or superintended by the old carver, painter, or sculptor.

The term "mason" must be interpreted in a very wide sense. Regarding the various degrees of mason, master mason, king's mason, and king's master mason, we are to understand the term master mason as only applying to a skilful workman, in distinction from an ordinary one. Thus, in the disbursements for "taking doune the Auld Croce and building the New" in Edinburgh in 1617, seven or eight master masons are specified who were paid from £4 to £4 13s. 4d. per week, the ordinary being rated at from £2 10s. to £3 12s. In these operations a John Taliphère was the principal one employed. The name of John Milne also occurs, the same who was subsequently appointed principal master mason to the king on the decease of William Wallace in 1631; and one of a long succession in the same family similarly employed, the most prominent of whom was Robert, so well known in later times as an architect.

Specimens of early figure sculpture in Scotland are almost exclusively confined to the effigies on monumental tombs, many of which have unfortunately been destroyed or allowed to decay; those which remain have probably to some extent been preserved either from respect to the families with which they were connected, or a feeling of superstition in desecrating a burial place. Among those from the thirteenth century onwards, which have been spared us, may be mentioned the effigy of Marjory Abernethy, the lady of the good Sir James Douglas, who died in 1259, in the Old Kirk of St. Bride of Douglas. On the floor of the Chapel of St. Mary in Bute, in a state of most disgraceful neglect, is a figure of a chief, rapidly decaying, in pools of gathered rain. Of a ruder style, are two figures on the Paltalloch tombs, and several in Iona. Similar specimens exist in scattered localities, and in many out-of-the way places old graveyards are literally paved with stones, probably of the same period, covered with accumulations of soil and rank grass, such as those at Kilmartin and near the terminus of the Crinan Canal. Among the Douglas tombs is an interesting effigy of the good Sir James, who was killed by the Moors in 1330, but this, like the others, has been sadly mutilated—it is said by the Cromwellian dragoons. In the same place are two fine canopied tombs, still bearing traces of their former gilding and painting. One of these, very much restored, contains the decayed figure of Archibald Douglas, 5th Earl, 2nd Duke of Tourraine, and Marshal of France (died 1438), with five remaining out of six small upright canopied figures on

the base, extremely quaint and elaborate. The other, which is less elaborate, but of superior execution, contains the broken effigies of James the Gross, 7th Earl (died 1438), and his wife, Lady Beatrix Sinclair. The latter is surmounted by a full heraldic achievement; the base contains six small male figures—one habited as an ecclesiastic—and four female figures, the head-dress on the last of which is supposed to indicate her unmarried state, the two series being separated by impaled and quartered arms bearing the Douglas heart and stars, rampant lion, and wavy St. George's Cross. On the latter tomb, the carvings over the mouldings are extremely good, and bear a very close resemblance to similar details on parts of Melrose Abbey, possibly executed by the same carvers. Among other tombs of the same kind and period may be mentioned those of the Forresters in Corstorphine Church; and at the time of their erection probably few such places in Scotland were without similar monuments, as among such as still remain many are connected with comparatively unimportant personages. Even in quite recent times the want of care of such works is most notorious, and will easily account for the many empty niches observable on a great number of our old edifices. Thus, the very beautiful effigies of Sir John Colquhoun and his lady, in full costume of the middle of the fifteenth century, were long allowed to lie uncared for in a wood where the children of Houston village played at leap-frog over the prostrate figures; and the two wall tombs, with one or two others in St. Mary's in Bute, are even now mouldering out of all interest, for want of a trifling expenditure towards their preservation.

Perhaps the most magnificent specimen of Scottish monumental sculpture of the brilliant fifteenth century is the splendid canopied tomb of Bishop Kennedy in the College Church of St. Andrews, from which, unfortunately, the recumbent figure is gone. Speaking of this work, Mr. Billings says, "in very few such works have architectural forms and devices been so profusely and gorgeously heaped together as in the rich monument of black marble erected to the memory of Bishop Kennedy. Towers, pinnacles, crockets, canopies, arches, pillars, mimic doors and windows, all have been thrown together in rich yet symmetrical profusion, at the will of some beautiful and fantastic fancy, as if a fairy palace had been suddenly erected out of the elements of feudal castles, of minsters, abbeys, cloisters, and vaults." He was the founder of St. Salvator's College, and died in 1466. Pitcottie refers to him as having

"foundit ane triumphand Colledge in Sanct Androis, called Sanct Salvitouris Colledge, quharin he made his lear verrie curiouslie and coastlie, and also he biggit ane schip, called the Bischopis barge; and when all thrie were compleit, to witt, the colledge, the lair, and the barge, he knew not quhilk of thrie was costliest; for it was reckoned for the time, be honest men of consideratioun, that the least of thrie cost him ten thousand pund sterling," an estimate which must, however, be taken with some caution. Although important works of this kind and period are rare, the profusion of architectural enrichments of a high class still existing on the castles and ecclesiastical edifices of the north testify to the taste of the wealthier Scottish nobles and prelates. Such buildings as Falkland, Glamis, Elgin Cathedral, and Roslin Chapel are sufficient evidence, and, with many others, are too well known to require any reference here. Time and the hands of the destroyer have been especially severe on the old carved fonts, few of which now exist; one at Dryburgh has already been alluded to, and another of equal interest is well cared for in the old church of Fowls Easter, where a magnificent fifteenth century painting of the crucifixion is also preserved.

Of the numerous figures which once adorned the exteriors as well as the interiors of our churches, one of the most beautiful remaining is a winged St. Michael on one of the angles of the church of that name in Linlithgow. Much decayed and mutilated as it is, the pose of the figure trampling on the dragon is still perfectly preserved, the action of the right hand grasping the misericorde, and of the left arm (the hand of which has been holding the spear) being yet evident. The unhelmeted head is of a feminine character, with long flowing hair; the body is covered by what seems to have been close-fitting chain mail, with tassets or skirts of the same, and on the lower limbs the central ridge or angle still discernible in a sharp side light, with some marks under the left knee, indicate rather the character of plate armour than the softer rounding which would have yet remained if a mail covering had been represented. This figure thus possesses a certain amount of interest from being treated in a somewhat ideal manner; the costume is rather traditional, and of an earlier date than the probable period of its execution, and the presence of the wings, the long hair, and feminine face, indicate an effort on the sculptor's part to convey his ideal of the archangel rather than an image of a person of the time.

"Of all the palaces so fair" in Scotland, that of the neighbouring one of Linlithgow stands pre-eminent, not only on account of its historical and architectural importance, but for its sculptured remains. Much decayed, weather-worn, and mostly in fragments, the old fountain in the centre of the quadrangle still forms an appropriate ornament to the royal dwelling. Almost as much decayed are the sculptures on the outside over the main entrance, and those on the wall on the east side of the court, on which under a fretted canopy, the centre is occupied by the head, shoulders, and arms of a St. Michael, whose outspread wings dominate a crumbled and empty niche, formerly containing, it is said, a pope. On each side of this is the upper part of a winged angel bearing a scroll and flying upwards, which still show traces of great spirit and execution, and the motive of which is most apparent in the early part of a sunny day, when the light falling from the south-east almost converts them into semblances of flying doves. Under these the niches are said to have contained figures of a knight and an agriculturist, thus representing the three estates dominated by angelic powers. Of the group formerly over the south entrance (also inside the court), all that now remains is a figure of the Madonna with upturned face, hands folded on her breast, and long flowing hair; in this figure also the rude Scottish climate has failed to obliterate traces of its original grace. The date to which these portions of the palace are assigned is early sixteenth century: who the artists were of course it is impossible to tell, although tradition assigns them to the skill of a Frenchman. More probably they were Flemish, as tapestries, &c., were imported from Flanders for the furnishing of the palace. It is a beautiful instance of fine feeling in what we are accustomed to consider a rude age, which prompted the fifth James thus to decorate his dwelling for the reception of his bride from France, and to carve on one of its apartments the charming motto, "*Belle a vous leule.*"

Of the numerous once-existing specimens of this and the following century, almost none have escaped the wrath of the reformers. The agitation that convulsed England was but as a gentle tremor compared with that in Scotland. For many years the cry was for purging the Kirk, casting down images, and forbidding of "pensils and brods" in the sister art of painting. What could not be burnt after being thrown down was destroyed, and fortunate was the monastery or abbey church which escaped having its roof

loosened, and allowed to fall into the ransacked choirs. Any semblance of a cross was more especially an object of hatred on the part of the reformers, and thus any such monumental sculpture in this form, which existed on public roads or other places, met with but little respect. So little sanctity, not to speak of respect, even in the present century, has been attached to such, that many instances of their removal and destruction have occurred. One of the most amusing and characteristic is that of two Highlanders who were hindered some years ago by the farmer on one of the islands near Loch-na-Keal at Mull, from bearing away one during the night, in a boat which they had brought for the purpose, in order that they might erect it elsewhere as a mark of respect over the grave of a parent. We all know too well the vandalism of the people for a long time after the Reformation, by no means confined to the poor and ignorant classes, which led them to look upon the neighbouring abbey or cathedral as a convenient quarry, from which stones were freely removed for ignoble purposes; and thus many a bit of sculpture came to be used for terminating the corner of a barn, or for insertion in the wall of a dwelling-house. Of this class of sculpture, perhaps the most beautiful example in Scotland is a fragment in the old churchyard at Kilmartin, of probably the fifteenth century, bearing on one side a carved figure of the crucified Saviour in high relief, which will compare favourably with any sculpture of the period north of the Alps. The outstretched arms are gone, but the drooping head crowned with thorns, the supine limbs, graceful form, and soft modelling still show evidence of it having been a beautiful work of art. The other side bears the lower part only of a flat treatment of God the Father, in a Byzantine style. It is said to have been associated with the memory of St. Martin of Tours, and formerly stood on the roadside in the neighbourhood, from whence it was removed and laid in the churchyard protected by turf, after which it was erected where it now stands on one side of the path within the gateway, opposite to another of similar size and form covered with the usual geometric pattern.

During the Reformation no greater blow was given to any of the arts than that which the art of sculpture experienced. Although ecclesiastical architecture was also arrested, and barn-like structures only were erected, such having been esteemed good enough for the services of religion; yet that art was to some extent kept alive by the erection of private dwellings of some

pretence to art by those who could afford to do so. Although the painter's art hardly existed in Scotland, individual vanity still kept some mediocre painter's brush at work in the line of portraiture; but the unwritten laws of the reformed church as clearly forbade the introduction of sculpture into places of worship or upon graves, as strictly as those promulgated by the old Nicene Council regulated the forms and types which art was to follow. Thus, throughout the Reformation and succeeding period, it may be said that no sculpture worthy of the name was produced in Scotland. Funereal monuments were of the plainest kind, bearing nothing beyond the name, age, and virtues of the deceased, dependent on the chisel of some enthusiastic "Old Mortality" for later preservation. Even after the religious troubles had been succeeded by the Rebellion, the art only began to assert itself in the most ignoble manner. Obscure country masons cut hatchments for the decoration of mansion gateways and entrances, their work being sometimes varied by rude devices on stone panels, and hour glasses, skulls, and hideous-winged monstrosities, such as are to be seen in old parish grave-yards. The application of the art in any other form than as an aid to architecture was till then unknown in the country, and, in consequence, generations had to pass away before old prejudices were outlived, and other uses for the art became possible. Although a few monumental groups had been executed for families powerful enough to be careless of popular opinion, as some carvings at Holyrood and elsewhere, they were not the works of native artists. It was not till the latter part of last century, when a feeling for poetic literature began to burst the bonds of bigotry bred by ecclesiastical abuses and prejudices, that some attempts at sculpture in the form of an art began to appear.

It would be an interesting question, if time permitted, to inquire how far the presence of proper stone in localities affected the freer introduction of sculpture in some early Scottish edifices. The superabundance of enrichment on such buildings as Melrose Abbey and Roslin Chapel might be contrasted with the Chapel of King's College at Aberdeen, where the interior is void of sculpture, and the decoration is entirely dependent on the very magnificent oak screen and canopied stalls, which are hardly equalled in any church in Europe. Although this church is built of freestone, the general prevalence of the hard granite of the locality would not afford practice or training for the local stone carvers; and,

besides, the cost of transit of the material may have had an influence on the production of a good class of carvers in wood. Even had the injunctions of Knox and his colleagues been carried out to the letter, to spare the doors, desks, windows, and such like, there would have been more specimens of this beautiful art left us than those at Dunblane, Fowlis, &c., the various fragments in the Scottish antiquarian collection, and the scattered panels from Stirling Castle.

XI.—*On the Plate River System.* By JOHN GALLOWAY.

[Read before the Society, 7th March, 1888.]

THE subject of my address to-night is the great rivers of South America, which empty themselves into what is known as the River Plate, together with some remarks on the countries through which they flow.

With a subject so great, and at the same time so varied, I have several difficulties to contend with, in endeavouring to overcome which I must throw myself upon the indulgence of my audience. There is the vastness of the subject, as also the necessarily short time at my disposal, and the great variety of detail connected with it, in which I am apt to get confused myself, and to lead my hearers into confusion; and there is, further, the danger of thinking that because I may have a clear idea of things myself, therefore my short and inadequate description conveys an equally clear idea to the minds of those who are listening to me. Knowing these dangers, I shall endeavour to avoid them, and if I fail, I can only, as I have said, throw myself upon the indulgence of my audience.

The subject itself is one of intense interest, whether we regard it simply in its physical aspects, where everything is of gigantic proportions—immense rivers, immense plains, immense forests, and equally immense mountain ranges; or whether we regard these countries as the future home of a mighty nation—the land ready to receive—the furnished lodgings for the teeming millions of Southern Europe—the present sphere where our superabundant capital is to be employed—the future market for our manufactured goods; or as one of the great suppliers of the world's food. In one and all of these aspects it cannot fail to interest every intelligent man.

Whilst the physical aspects are interesting, it is not until the human element comes in that different and more powerful impulses in our nature are appealed to and drawn forth. You see a painter portraying a Highland moor so true to nature that you can almost feel the fresh and balmy breath of the mountain air, and you

admire the truthfulness with which he has depicted everything upon his canvas ; but if there is no indication of human life the picture as one which appeals to our better nature is wanting. It is not until he puts in the roof of a half-hid cottage, or a curling wreath of smoke to tell that some member of Adam's scattered family is there, that the picture possesses an interest which otherwise it wants. So I take it that the human element will prove the chief feature of interest in my address to-night.

It was in 1492 that the great Columbus discovered the New World, and in an incredibly short time the whole of the eastern shores of America had been visited by the adventurous voyagers of those early days, by whose exertions a new era in the world's history was breaking upon mankind. In the year 1515 the River Plate was discovered by Juan Diaz de Solis. Twelve years later the celebrated Sebastian Cabot sailed up the Parana and Paraguay, and in 1535 Pedro de Mendoza founded the City of Buenos Ayres. From that date the Spaniards obtained a firm footing in these lands. Their rule, however, cannot be commended as good or wise in any sense of the term ; the cruelties which characterised them in other parts unfortunately obtained here also, and, indeed, the Jesuits were introduced as much for the purpose of defending the natives from their conquerors as for the purpose of converting them to Christianity. I cannot say how far they were successful in the former, but in the latter their success was astonishing, as in thirty-seven years after their introduction they had no less than 110,000 neophytes. It is an interesting fact that in 1806 the whole of this immense country nearly passed under British rule, the deed of cession being made out ready for signing, and the parties gathered together for the purpose of appending their names, when, through the gross blundering of the English General Whitelock, everything was lost, and the Buenos Ayreans to this day preserve with patriotic veneration some British balls which have got lodged in one of the city church towers.

In 1810 the colonists threw off the yoke of Spain and set up house for themselves. I cannot say, however, that their house-keeping was of a superior description, or that for many long years they were the better of the change. The country became the prey of upstart adventurers, and in 1828 it was divided into five separate and independent States, each at war with the other. It was at this time that a farmer named Rosas, clever, but cruel and

unscrupulous, rose rapidly to power, subdued the various rival sections, and endeavoured to bring Uruguay also into subjection; but in this latter he failed. His whole rule was a reign of terror, during which life and property were alike insecure, and in which all foreign trade was discouraged; and in his attempt to carry out this policy he provoked a war with France and Britain by closing up the navigation of the rivers. In 1852 this tyrant fell. It could not be expected that a country which had come through such a training would settle all at once into the peaceable ways of life which are recognised as needful for the progress of nations, or the development of their resources; and, accordingly, we find that it is only within the last ten or twelve years that revolutionary tumult has ceased, and that, from various causes, the central government has got the power to enforce the laws, and to turn its attention towards the development of the vast resources of these countries.

The history of Uruguay is somewhat the same, only the time when law and order began to prevail comes down to a much later date.

Paraguay stands by itself, and has a story so romantic, and at the same time so unique, that I pass it over in the meantime; but, if time permit, will refer to it more particularly further on.

I am thus particular in referring to the history of these countries, because there are those amongst us who, unacquainted with these facts, cannot understand how countries with such vast resources and with such facilities for trade should have remained so long in the background of the nations, and all but unknown to the world's commerce.

With this preface, I now turn to what may be regarded as the proper subject-matter of my address. And, first of all, let me explain that what is known as the River Plate is, in reality, no river at all, but an arm of the sea. A glance at the accompanying map will suffice to show this. Were it in Scotland we would call it a loch, or in Norway a fiord. I suppose that its Spanish discoverers, finding its waters fresh, in consequence of the immense volume of water emptied into it by the Parana and Uruguay, were unable to dissociate this state of things from the idea of a river, and accordingly gave it this name. Plate means silver, and Argentine has the same significance. How silver came thus to be associated with a region in which it is not to be found, I cannot say; all the explanations I have heard appear to me to be fanciful.

At its upper extremity the Plate is about 20 miles wide ; but the shores are so low that the one side cannot, even at this its narrowest part, be seen from the other. It gradually widens until, at Monte Video, it is 70 miles across, and at this point it may be considered geographically as ceasing.

It is into this arm of the sea that the great rivers Parana and Uruguay empty themselves ; and I may anticipate my subject so far as to say that the volume of these rivers is so immense that the Parana, the larger of the two, empties no less than 41,000,000 cubic feet of water every minute into the Plate ; and if we add to this the 11,000,000 discharged by the Uruguay, we have a total of 52,000,000 cubic feet discharged every minute. Now, the waters of both these rivers, but especially of the Parana, are very turbid. They flow for the greater part of their immense length through plains of clayey soil, and the consequence is that their waters are never clear, having the appearance of our Clyde during a winter spate. If you take from the river at any time a tumblerful of water, and allow it to settle, a very appreciable deposit of earthy matter takes place, and one can scarcely conceive the tremendous amount of solid material which is thus conveyed by these great streams from far inland to the sea. So great is the amount of fresh water discharged into the Plate, that 80 miles from the point of *debouchement* the water is quite fresh, and at 120 miles it is still brackish. You will, therefore, not be surprised to learn that under these conditions the Plate is rapidly being filled up, and that it has immense shoals, which make the navigation both difficult and dangerous. At Buenos Ayres oversea ships are obliged to lie twelve miles off, and even vessels drawing only eight feet of water cannot approach nearer than a mile. Some people are inclined to blame the founders of Buenos Ayres for building the city where it is, but I am not sure that they are blameworthy, as I think that 300 years ago the conditions of things, so far as depth of water is concerned, was very different from what it is now.

I was much interested in the delta of the Parana. One would have thought that, under the conditions I have named, this delta would have been very large, while the fact is, that it is considerably less than those of the Nile, the Ganges, or the Irrawaddy—all of them much smaller streams, thus affording proof of the correctness of the conclusion to which geologists have come, that the South American is the youngest member of the family of

continents, and that even the Andes, with all their pretensions, cannot "hold a candle" to our own Highland hills. Let the Grants, who had a boat of their own at the flood, rejoice in the fact!

This smallness of the Parana delta is all the more remarkable that the river, if I may so put it, has special facilities for forming such. The freshness of the water in the Plate, for instance, permits of the vegetation upon the islands and mud banks of the delta to push itself not only down to the water's edge, but into the water itself; and every one knows how, in such circumstances, a dense and luxuriant vegetation has a mighty influence in the making of new land. Another great factor in this process is the presence of vast numbers of camelottas or floating islands. These are formed of a large-leaved water plant, which, when cut up, is found to have an immense number of air cells in its stems and leaves, possessing thus a great floating power. These have the habit of growth which enables them to intertwine their roots together until, it may be, a vast number are laced together in one mass. When the river is low they grow in the entrance of creeks, the lee of islands, and other sheltered places with wondrous rapidity, and when it rises they are floated off in great numbers from one yard to 100 yards in diameter; and such is their buoyancy that pumas and jaguars have been known to be carried away by them. It can easily be understood that when such islands ground upon a sand-bank or are caught in a snag, or by the two banks in some of the narrow channels of the delta, the result is the stoppage of the flow of water immediately under, and that in consequence a deposit of earthy matter takes place; and in this way shoal or island is formed.

I passed on one occasion through the Las Palmas Channel from the Plate into the main river, and it was very interesting to notice the records we had of the progress of deposit. At first we had indications of land, by the presence of immense quantities of reeds growing out of the water; further up in the midst of these we had perhaps one or two bushes struggling for existence in their watery bed, and doing their best to assert their victory over the river gods. Still further up the bushes increased, until their places were taken by trees, which upon the full-formed islands became dense and luxuriant; and thus the unequal fight goes ever on, old ocean being ousted, and gradually driven back, by the silent but ever-working and pertinacious efforts of the mighty rivers.

As I have said, there are two great rivers which empty them-

selves into the Plate. These are the Parana and the Uruguay, and to these I must add the Paraguay, which, although it is an affluent of the Parana, has yet such a long independent course, and is so important to commerce, that it deserves a distinct place in such a paper as this.

The Parana is the longest, and, in many respects, the most important of these. It has a course of 2,300 miles, and, as for the greater part of its course it divides itself among innumerable islands, it is difficult to gauge its size. At San Pedro, however, it runs in one bed, and, as this is shortly before it divides into the delta channels, it is a good point at which to do this. Here we find that it is 1,600 yards wide, 70 feet deep, and has a flow of about $3\frac{1}{4}$ miles an hour. The size of the Uruguay is only a fourth of the Parana, and yet, it is larger than the Nile, and as large as the Ganges.

In sailing over the waters of the Parana, one cannot fail being struck with its immense volume of water, dwarfing all our preconceived ideas of what a great river should be; and there is something extremely grand in the wide sweep of the great flood as it flows in stateliness and majesty from its far-off mountain sources, towards the great ocean, carrying on its bosom the traffic of a multitude of towns, each the centre of human labour and enterprise, and forming nature's great highway, reaching far into the centre of the continent.

The amount of traffic is very wonderful, and this in a great measure is carried by native river craft, for the most part schooner-rigged, and of from 200 to 500 tons. I was much surprised at the extreme beauty of these vessels, having lines almost as fine as those of a yacht, carrying an immense spread of sail, all of which is made of white cotton cloth. They sail with great swiftness, and are extremely beautiful, as, like sea birds, they pass along on their several ways. In the lower reaches of the river the towns are numerous, such as San Fernando, Campana Buradero, San Pedro, San Nicholas, Ramallo, Lopez, Rosario, San Lorenzo, Parana, and Santa-Fè; but as you ascend, the interval between the towns becomes greater, and you sail past vast tracks, without trace of human being—a land waiting ready to receive its future inhabitants; and being level as a bowling green, and without trees, it does not require the labour of clearing, as do the Canadian backwoods; it is ready for the ploughshare, and the first year after settling an abundant harvest may be reaped.

As you ascend the river, you pass the provinces of Entre Rios and Corrientes on the right. The first name means "between the rivers:" a glance at the map explains the reason why. It is identical in meaning with Mesopotamia, and for the same reason, and like its ancient namesake, it is a Goshen of fertility.

It is extremely interesting to visit the various towns on the passage up. The eye of the European traveller recognises at once the picturesque costumes of Spain and Italy, reproduced in the new world. At several points, such as Parana and Corrientes, I saw tall, strong, swarthy fellows in light cotton trousers, with gaily-coloured flannel shirts tied in at the waist with scarf, and the whole surmounted with picturesque head-gear, driving sleek and meek-eyed oxen yoked to curious high-wheeled carts—a sight which, in all its varied details and harmony of colour, would have delighted the heart of a Rosa Bonheur. These towns are all built upon the same plan. A square, planted with trees, occupies the centre, and in the midst there is to be found the never-failing monument to liberty. Upon one side of this square is always to be found the town church or cathedral, and upon another there are generally the municipal buildings. From this centre the streets run out in straight lines, and are crossed by others at right angles and at regular distances, forming blocks or squares, all of which are of the same size, so that measurements, even outside of the towns, are stated as being so many squares.

The houses, however, interested me most of all. Many years ago I had wandered through the streets of Damascus, and there examined a form of house which probably had its origin in that oldest of all earth's cities, far back in the mists of a past antiquity. A house consists of a court, sometimes two, in the centre of which there is either a fountain or small garden plot, and with each room opening to the centre. This kind of human dwelling has travelled towards the west, carried apparently by the descendants of both Japheth and Ham, from the cradle of the human race, by the one great branch of the human family, through Asia Minor into Greece and Italy. It has been superseded by more modern ideas in these two latter countries; but its presence there in ancient times is proved by its being found in ancient Pompeii. It was carried by the other branch along the northern coasts of Africa, through Egypt, Tunis, Algiers, and Morocco, where it still exists; by the Moors it was carried into Spain; and by the Spaniards it has been taken across the Atlantic, to gain firm root in the New

World. Standing in the courtyard of one of these houses, I could almost fancy I was standing in the midst of a Pompeian house restored, the only want being the beautiful decorations which Greek and Roman art put upon their walls. It was with extreme interest that I thus met at the end of the earth the outcome of a human idea which reached away back to the infancy of our race, and so far from the place of its birth.

In the lower reaches of the river, owing to its immense width, to the perfectly level country through which it flows, and the sameness of vegetation, the scenery is not interesting, and one, especially a Scotchman, accustomed to the beautiful variety of outline, and of light and shade upon hill and dale, is inclined to exclaim—

“ My heart's in the hielands,
My heart is na' here.”

As you ascend, however, this considerably changes—the cliffs on the side of the river rise to a height sometimes of 200 feet. You get beautiful vistas among the islands; the vegetation becomes more luxuriant and decidedly more tropical—brakes of bamboos and groves of orange trees, intermixed with feathery palms, giving an interest to the scenery it did not previously possess; and at some points the view is simply enchanting. This is especially so at Bellavista, or “ Fine-View,” as the name imports. It is situated on a high cliff, and you can climb the church tower built on the top, and from this vantage ground you get a magnificent view of the mighty river divided into some seven great streams by wooded islands, from between which, and from behind height and-promontory, the waters of the Parana reflect the brilliant sunshine; and far beyond, away to the hazy horizon, you have a view of the richly-wooded country. Another point of great beauty occurs after the steamer leaves Corrientes and makes for the entrance to the Paraguay, threading its way among beautiful islands, densely wooded, and ever and anon it sails out into the wide undivided waters of the great stream. At this point, although you are fully 700 miles from the sea, and the stream is seven miles wide, you look with something akin to amazement, as you see the great river, with which you are about to part company, bending towards the east, where it gathers together its wealth of waters from many a far-off hill and dale, where, as yet, the foot of the white man has never trod. As I gazed at this point upon its mighty waters, beneath a calm blue sky, and glittering in the rays of a brilliant

son. I got an idea of the vastness of the river such as I had not had before.

As we enter the Paraguay the scenery becomes very beautiful and interesting, and the first human dwelling upon the bank to our right tells us that we have changed from the territory of one nation to that of another. The flat-roofed houses of the far-off east are left behind, and now we have the slope-roofed houses peculiar, in this part of the world, to Paraguay. The river is narrower, although still of great size, and as we ascend there is greater variety, until at last we have the refreshing sight of distant hills, all of which are wooded to the summit. Around every little town-ship there are large orange groves, the golden fruit looking beautiful from among the dark green leaves. It is very interesting to watch the method of loading these upon the vessels which are to convey them down the river. The oranges have been previously carted from the groves to the river bank, and there laid in immense heaps, and when the steamer is fastened to the outer extremity of a thin wooden pier, some fifty or sixty women, who have been waiting her arrival, set to work with an energy and a will which are remarkable. Each one fills her basket, places it upon her head, and walks lightly to the steamer, where she is relieved of it; they come and go, tripping and dancing, singing and laughing—not a few of them smoking, and doing their work with a steadiness and an alacrity which astonished me. I saw such a band of women at work in this way for five hours without flagging, and during this time they put 250,000 oranges on board of our steamer.

Whenever we enter the Paraguay crocodiles make their appearance. Big, black, and slimy, these repulsive-looking reptiles lay in great numbers upon the banks, and afforded great amusement to those passengers who were possessed of rifles. The vegetation now became also very beautiful, but the gem of all the trees which I saw was the lapacha, a tree which produces a valuable hard wood. In size and shape it is somewhat like our elm. In the spring, and previous to any leaves coming out, it is densely covered with beautiful flowers, in size and colour like those of the common rhododendron. As you stand before one of these graceful trees, loaded throughout with magnificent flowers, it is a vision of beauty which you are not likely to forget.

Asuncion, the capital of Paraguay, has a population of about 25,000. It is a curious, old-fashioned, straggling, ill-paved town, but finely situated, and with most beautiful surroundings. It is

intensely interesting as being the capital of this brave Republic, whose inhabitants have shown qualities of heroism and endurance, than which ancient Sparta never displayed better.

In 1865 the ruler of Paraguay was one Lopez, the second of the name. He had visited Paris, where he had come under the influence of an evil woman, whom he brought with him to Paraguay, and he formed the idea of becoming the Napoleon of South America. Had he possessed the genius of that great man, it is more than likely he would have accomplished his purpose. But of genius he had none. He was cruel and unscrupulous, and he, unlike his subjects, was a coward to the very centre of his miserable backbone. He declared war against the Empire of Brazil, and the Argentine and Uruguayan Republics, and although his army was miserably armed, badly clothed, half starved, and vastly outnumbered by the enemy, who had all the appliances of modern warfare in cannon and rifle, as well as iron-clad gunboat, the war was continued for six years, during which the Paraguayans displayed a bravery and a courage which one can only lament should have been wasted in endeavouring to further the ambitious schemes of this miserable tyrant. At Pass la Patrie 60,000 of the allied army, provided with all that modern science could supply, were held at bay for six months by half their number of ill-armed and ill-clad Paraguayans. At Curupati 8,000 Paraguayans, mostly boys of from sixteen to twenty, drove three times their number before them in panic, sacked their camp, and compelled them to remain inactive for months. At Humaita 3,000 Paraguayans, with every disadvantage, held out for four months against 20,000 allies, backed by iron-clads and monitors. In innumerable battles and skirmishes, and by long and weary marches, naked and starving, these Paraguayans fought with a heroism which claims our highest praise and most unstinted admiration. As I have said, led by a man of military genius there is almost nothing such a nation could not have done, but led by a poltroon and a fool, they were rewarded by the man they served all too faithfully with the most brutal cruelty, and sacrificed by tens of thousands to his utter incompetence. And when, at the end of six long, weary years, the war was brought to an end by the death of the tyrant, the nation was on the point of being exterminated. Women perished in vast multitudes, but, as might have been expected, the brunt fell upon the other sex, so much so that when, at last, fighting ceased there were thirteen

women to one man, and even yet there are three or four. The land, one of the fairest and most fruitful in the South American continent, was reduced from being like the Garden of Eden to a wilderness, and like a felled ox the whole nation lay prostrate and powerless. But for mutual jealousies it would have been absorbed by one of the contending parties, and for many years it remained so enfeebled as to be unfit for almost any national action. Now, however, it is recovering strength and purpose of will. The people are kind, gentle, law-abiding, and industrious. The Government appear to have the good of the country at heart, and are giving every facility for the development of its latent resources.

One of the sights of Asuncion is the market-place, and once seen it is not likely to be forgotten. It is a large building, with an open court in the centre, in which, especially in the morning, there are congregated hundreds of the somewhat dusky dames and damsels of Paraguay, all of whom have their toilet of a very primitive description, consisting of what we would call a night-gown, with sometimes a small shawl or handkerchief around their shoulders or over their heads. They are of ordinary height, but very erect in bearing, brought about by the habit of carrying everything on their head. They are a merry, cheerful, and hard-working race of women. Crouching, or, as we would call it, "hunkering," before tables, there they are, selling all kinds of produce and manufacture — tobacco, oranges, lemons, citrons, sweet potatoes, yerba or native tea, manioca, melons, parrots, monkeys, cardinal birds, cotton cloth, pottery, smoking pipes, preserved fruits, sweets, cheap jewellery, bread, various kinds of hot native dishes cooked on the spot, and a host of other articles. The bartering goes on in the midst of a babel of sounds, in the midst of which the loud, clear laughter ever and anon comes in to tell us that the well-springs of mirth and gladness are flowing in the hearts of those poor toil-worn daughters of Paraguay.

I visited Paraguari, a town about 45 miles inland from Asuncion, also the Lake Ipacauri. The country is exquisitely beautiful. The hills, not above 1,000 feet high, are yet bold in outline, finely varied, and richly clothed in luxuriant vegetation from base to summit. I also visited Concepcion, a town about 240 miles further up the Paraguay, and here life was still more primitive, and in consequence more interesting. At this point, hearing there was a tribe of Indians in the forest on the other side of the river, I obtained a guard from the Custom-house, and

visited them. They were, without exception, the lowest type of humanity I have yet seen—big, fat, clumsy, with very forbidding countenances, and long coarse black hair. They were intensely filthy, the dirt being literally caked upon their skins. Their dwellings are simply wattles and branches of trees laid together like the roof of a house, and under this shelter they lie upon the ground, being naked, with the exception of a loin-cloth covering. One thing which struck me was that, notwithstanding the clumsiness of their bodies, I never saw neater ankles and feet, wrists and hands; and there is not a lady in the land who might not be proud of the possession of such of these as were possessed by the most unprepossessing female among these poor outcast members of Adam's great family. They inhabit the great Chaco, or forest, a region as large as the whole of England and Wales, in the depths of which they hold their own against the white man, and but for this protection they would long ago have been exterminated. They are easily civilised, and I was assured by those who employed them that they made faithful and industrious servants. I am sorry that since the days of the Jesuits no organised attempt has been made in this direction, and that but too frequently there has been instead a cruel war of ruthless extermination, they being regarded as little better than wild beasts.

With peace, I think the future expansion and prosperity of Paraguay are assured, and, as I have said, it is already awaking up to new life. I visited it on two occasions, with an interval of exactly a twelvemonth between, and I could scarcely have thought it possible that in that short time there could have been such a manifest improvement, an improvement which appealed to the eye of the most careless, and this especially in the dress of the natives. On my first visit, speaking roughly, 19-20ths of the females wore the very primitive dress I have already described; on the second, one-third, I should say, had shoes and the cotton wrapper so common amongst ourselves. I am assured by Dr. Stewart, the British Consul at Asuncion, that foreign capital is flowing into the country as it never did before, that labour is so plentiful that no one need be idle, and that want is all but unknown; and indeed this applies to all the River Plate countries. I saw more wretchedness and misery in Liverpool in the 20 minutes after I landed than I saw during the nine months I spent in these lands. They have not yet known the inestimable blessings conferred upon mankind by strong drink; no doubt, when they learn this secret they will be

able to advance towards the same standard in the scale of civilisation which we possess, and be able to sing with Scotchmen :—

“ Lees me on drink, it gies us mair
Than either schule or college ;
It waukens wit, it kenles lair,
It pangs us fu’ o’ knowledge.”

One of the products of Paraguay is tobacco, which smokers say has a peculiarly fine flavour. An old Jesuit writer who, nearly 300 years ago, lived at Asuncion, calls it “the Divine weed,” and a modern writer, after enjoying a smoke at the same place, exclaims “what blessing can equal a good cigar.” Then there is yerba, or native tea, an herb possessing many of the qualities of China tea, but more exhilarating, and which is largely used in all the surrounding countries. Coffee grows, and, so far as the climate and soil are concerned, there appears to be nothing to hinder the cultivation of tea. Sugar-cane grows to perfection. The forests have a great variety of trees, the woods of which are valuable, while the plains and slopes are admirably adapted for the growth of all kinds of grain and for the rearing of horses, cattle, and sheep. Almost any plant requiring heat and richness of soil could be cultivated here, and doubtless, now that the nation is free from its former tyrants and is beginning to realise the possibilities of its position, many of these will be introduced. Unquestionably the throbbings of a new life have already begun to beat in the heart of the nation, and the commercial enterprise which first enters in and takes advantage of the position will reap the full reward.

But I fear that I have spent too much time upon this part of my subject, and must now turn to others at least equally important.

Buenos Ayres is unquestionably the great commercial centre of these regions. In the southern continent of America it is the counterpart of New York in the northern. A city containing 500,000 human beings—a very beehive of industry and enterprise,—it has of late years progressed more rapidly than any city in the world, Melbourne alone excepted. So lately as 1852 it had only 80,000 inhabitants, but since then it has strengthened its stakes and lengthened its cords until the half million has been reached—the stepping-stone to a greater number, which is being rapidly attained. This city is built upon the banks of the muddy Plate, and on the edge of a vast plain extending to the west, to the north, and to the south, for hundreds upon hundreds of miles, perfectly level; and when you get away from the towns, there is

not a tree to break the monotony of the scene. Indeed, the only tree indigenous to this part of the country is the ombu, a very beautiful tree, having very much the appearance of an oak, growing sometimes to an immense size; it is, however, of no commercial value, the wood being so soft that you can push a knife up to the hilt in its spongy tissue as it grows.

These vast plains, known in our geography books as the Pampas of South America, are the rearing places for vast herds of cattle and great flocks of sheep, and of late years they are fast becoming fields upon which great and increasing quantities of wheat, oats, and Indian corn are grown. One great want is the scarcity of stones, these vast plains not naturally possessing one as big as your hand. There are therefore none for road making, railway ballasting, or building; the roads in consequence are vile, the paving of the streets is very indifferent for want of a proper bottom, and all the buildings are of brick, covered with cement.

To Great Britain, which even yet has by far the largest trade with these regions, but which is being keenly contested for by foreigners, and especially by Germans, their progress is of vast importance, and it is passing strange to find such an ignorance among us of almost everything connected with them. It is, however, an important fact that more than any other country in the world the Argentine and Uruguayan Republics have progressed in late years. Both the people and the governments appear in some good measure to have realised the latent powers of their countries, and although they might, in some things, take wiser measures for developing these, yet, on the whole, they have been successful beyond all precedent.

Not content with the magnificent waterways with which nature has furnished them, railways have been pushed out from Buenos Ayres and Rosario, the two great commercial centres of the Argentine Republic, in all directions. It is only twenty years since the first railway was constructed, and now 4,200 miles have been built and opened, while the immense extent of new line which is either under construction or projected gives promise that the present length of line will before long be doubled. The lines which have been opened run from Buenos Ayres southward to Bahia Blanca—a distance of 500 miles, westward by the Central Argentine to the foot of the Andes, and there are now only 100 miles to make, in order to unite the Chilian with the Argentine systems; and there is a line northward to Rosario, while from the latter city lines

are carried westward to Tucuman and Mendoza, two cities lying at the foot of the Andes, and northward far beyond Santa Fè. All these trunk lines are connected by a network of minor railways with every town of any importance within the radius of their wide-stretching arms. It is proposed to extend the Tucuman line into Chili, and to construct one from Bahia Blanca to the same country, thus tapping the coal-fields of the west coast, and bringing produce and passengers from the one seaboard to the other in forty-eight hours, which at present, by the Straits of Magellan, takes fifteen days by steamer. In addition, the Messrs. Clarke of London are constructing immense lengths of railway in Corrientes and Misiones, and it is proposed to continue the present lines into Bolivia, one of the richest mineral countries in the world.

The development which has taken place in the material prosperity of the country justifies this great extension, of which it is at once the outcome and the cause. In order to give some idea of this development, let me state that in 1876 Argentine imports amounted to £7,000,000; in 1883 they were £15,000,000; in 1885 £17,000,000, while the exports for the same period amounted to £9,000,000, £12,000,000, and £15,000,000 respectively, the total trade for 1885 being £32,000,000, a larger amount per head of the population than in any country in Europe, except Britain, Belgium, and Holland. The revenue shows the same remarkable progress, it having increased three-fold since 1876, amounting in 1887 to £11,460,000. If we turn to Uruguay the total foreign trade in 1875 amounted to £5,000,000; in 1885 it had increased to £10,400,000. During 1886 309 steamers arrived in the Plate from Great Britain, and in addition there were a large number from Belgium, France, Spain, Portugal, and Italy, while 57 steamers arrived at Monte Video every month during 1886. Two years ago not one carcase of meat was exported; now the trade is represented by monthly shipments amounting to 20,000 carcasses. Up till 1884 not a single bushel of grain had been exported; in 1886 the value of the exports of this article amounted to £1,500,000. Again, if we examine the stock of sheep and cattle, which form the staple riches of the country, we find that while Australia is possessed of 72,000,000 sheep, the Argentine Republic has 100,000,000, or 25 sheep per head of the inhabitants, and the Republic of Uruguay has 42 sheep for every man, woman, and child within its borders, and these two republics possess 38,000,000 horned cattle. It is not

to be wondered at if in circumstances such as these emigrants are pouring into these countries, mostly from Southern Europe, the number of these arriving in the Argentine and Uruguayan Republics during 1887 having amounted to about 160,000; and year by year the numbers are increasing. These obtain great advantages from the Government, and settle down with great rapidity in their new homes, adding immensely to the wealth of the country; and when it is considered that the Argentine Republic alone equals in area the whole of Great Britain and Ireland, France, Spain, Portugal, Belgium, Holland, Germany, Austria, Hungary, Italy, and Greece put together, and that the present population does not exceed $3\frac{1}{2}$ millions, some idea may be formed of the extraordinary possibilities of the future. The Republic of Uruguay is equal to England and Wales, while Paraguay is about the same size as the United Kingdom. The population of the Argentine Republic has in 25 years increased 154 per cent., as against 79 per cent. in the same period by the United States.

A complete educational system has been introduced, being a copy of that adopted by the United States. The public schools are beautiful buildings, equalling those of our own board schools. The money appropriated by the State to this department equals \$10.20 per head of the population, being a higher proportion than is given by any other country in the world; our own country, which is the next highest, being \$9.10. The most complete religious toleration exists; and, as in Scotland, education is compulsory. Like most Roman Catholic countries the men are extremely careless about all religion, church attendance being left to the other sex, and in some large towns even they appear to pay little attention to such duties. In Gualaguaychu, for instance, there is no church, although it has a population of about 14,000. Service is performed in a small hall, and the walls of a church, long since commenced but never finished, attest the carelessness of the people. Whatever they may be in religious matters, there can be no doubt as to their business application, and I was frequently sorry to see how many, forgetting the higher and nobler things of revelation, betook themselves, with an ardour which admitted of neither rest nor relaxation, to the making of money, and I could not help concluding that the immense number of suicides in Buenos Ayres was to be accounted for by this incessant mental strain.

The people, however, are kind and hospitable to a degree that it would be difficult to find equalled in any other part of the

world, and money flows from them in a way that almost takes the breath from an ordinary Scotchman. This is all the more remarkable that Buenos Ayres is the most expensive city in the world to live in, being at least four times as expensive as with us. House rents are especially high. A house which in Glasgow would yield a rent of £40 would in Buenos Ayres bring £300.

The climate is one of the finest in the world, day succeeding day with a brilliancy and a splendour of which we in this land of clouds and mists are utterly ignorant. There are what are known as pamperos, strong south winds, frequently accompanied by rain, and in the winter season, bitterly cold; when a very severe gale comes it is called a *tormiento*. I was the witness of a very severe specimen. Two days previous to its breaking out, it was evident that there were very strong electrical disturbances, the sky being covered with cirro-stratus clouds of the most extraordinary size and appearance. On the following day, the sky was darkened with dense masses of cumuli, many of which were almost coal black, giving a weird and unearthly appearance to everything, and there was a little thunder and lightning. But it was on the third day that the tempest broke forth in all its fury. A hurricane of wind, accompanied by blinding rain, swept over the whole country. At Salto on the Uruguay, where I happened to be at the time, and which is 300 miles from the sea, the waves on the river were so high as to prevent all traffic for two days. One extraordinary effect of wind upon the Plate is the ebbing and flowing of the waters according to its force and the direction in which it is blowing. To such an extent is this the case that sometimes the fields in the neighbourhood of Buenos Ayres are flooded, and sometimes the water recedes for nearly a mile beyond the normal point, while on the occasion to which I have referred immense tracks were put under water, hundreds of cattle and horses were drowned, and, indeed, one family of five or six persons lost their lives in the same way.

The thunderstorms are very grand, and the play of the lightning is very curious; frequently the centre of disturbance from which forked lightning is being discharged is fringed with clouds emitting only sheet lightning, and every discharge in the centre is responded to by flashes of sheet lightning in the outskirts. I have never in this country seen one cloud discharge into another, it has always been either a discharge from the clouds to the earth or from the earth to the clouds. There, however, in every thunderstorm I watched I should say that at least one-half of the discharges were

from cloud to cloud. Frequently the electricity would leave the cloud as if attracted by the earth, and in its course be deflected by the superior attraction of some neighbouring cloud, and in this way be made to perform the most curious curves. Another curious phenomenon connected with these storms was the frequency with which more than one fork of lightning was discharged at the same moment. On one occasion I saw at least eight such forks, and as they zig-zagged in a curve from one cloud to another, and all in the plane of my vision, they appeared to intertwine the one with the other in a most extraordinary manner, making a display of celestial fireworks such as I had never witnessed before.

Let me close up with a reference to some of the disadvantages belonging to the country. I may do no more than name mosquitos and sand flies, as according to the modern theory each one of these troublesome insects is only a diminutive Dr. Pasteur, inoculating (especially new comers) with the marsh poison, so as to prevent marsh fever. They are thus blessings in disguise. But there is also the Beecho Colorado, a small scarlet animal which buries itself under the skin, causing most painful wounds. There are centipedes, poisonous spiders, and ants, the latter being most vexatious pests. These, however, are things which can be warded off. There are other evils more difficult to fight with. It will readily be understood that in a country so sparsely populated, and with so many of its inhabitants possessed of the hot impetuous temperament of Southern Europe, that away from the centres of population brutal murders frequently take place for the sake of plunder, while quarrels in town and country very often lead to the same sad result. In higher circles duelling is the common, and the most unreasonable way of adjusting difficulties, and this method not unfrequently ends fatally.

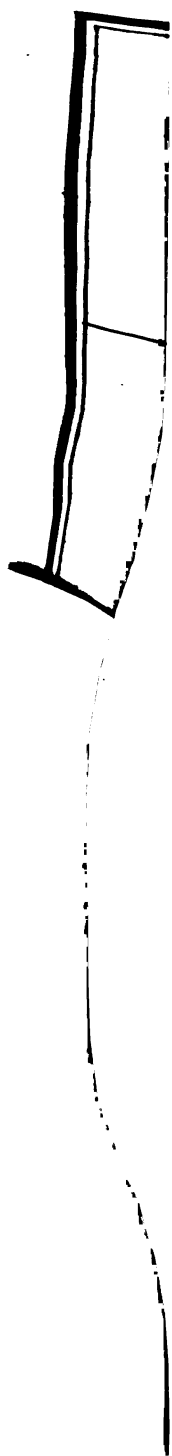
One great drawback to business is the want of a metal basis for the currency of the country, and the consequence is that the forced paper money in circulation is always at a discount. The amount of this depreciation fluctuates from day to day with every rumour, and with every ruse of the gamblers on the Bourse, and this to such an extent that within the past two years, it has varied from 116 to 151, or, in other words, it took 151 paper dollars at one time to purchase what at another could be got for 116. This upsets all mercantile calculations, and forces merchants to take enormous profits in order to cover possible losses, gives opportunities for wild speculation, brings about bankruptcies where none would

otherwise be, and, indeed, permeates all business transactions, putting them, more or less, upon a false basis. Another grievous hindrance to trade is the duties, levied for the purpose of protecting what are termed native industries. These take two forms, the one duties upon imports, and the other concessions to individuals carrying on particular trades, either giving them the sole right to do so, or money grants which make opposition impossible. But for these artificial restraints upon commerce I believe that, rapidly as the country is developing in spite of them, it would do so vastly more without.

Another great evil is the necessity there is for oversea ships which draw more than seventeen feet of water, lying a distance of twelve miles from the shore. The consequence is that the lighterage costs about as much as the freight from Europe, thus putting a tremendous tax upon commerce. New docks of immense proportions are, however, in course of construction at Buenos Ayres, and will probably be finished in three years, while at La Plata, a city about seventeen miles south from Buenos Ayres, immense docks, which would put any on the Clyde to shame, are in course of construction and should be finished in about a year hence; and as these have immediate access to deep water this will probably soon become a place of great importance to the trade of the country.

And now I must draw to a close; my time fails me, but not my subject. I would like to have spoken regarding the Republic of Uruguay and its present brilliant prospects; of the river Uruguay, of its trade, and of some curious phenomena connected with it; of the great Chaco or forest; of the city of La Plata, which only six years since had no existence, and is now possessed of a population of 35,000, and has buildings of which Paris or London might be proud.

I have endeavoured to give you a very brief and hurried account of these great countries, which are rapidly looming into view, big with the promise of a mighty future; and if I have succeeded in imparting information, in begetting an interest in their welfare, or in stirring up the business spirit of Glasgow to step in and take advantage of the open door which lies before her, I shall consider myself amply rewarded.



XII.—*Biographical Notice of the late Dr. Andrew Fergus.* By
EBEN. DUNCAN, M.D., President of the Sanitary and Social
Economy Section, and Professor of Medical Jurisprudence in
Anderson's College Medical School.

[Read before the Society 14th December, 1887.]

IT was with a universal feeling of deep regret and sense of loss that the community of Glasgow received, on the morning of 30th July last, the news of the death of Dr. Andrew Fergus.

At its earliest opportunity the Philosophical Society, of which he had been such a distinguished member, placed on record its grateful recollection of the services which he had rendered to the Society, and its sense of the great loss which it had sustained by his death. When we passed this resolution we also determined that a more detailed account of his life and life-work should be prepared. We felt that this was due to his memory, not only on account of the prominent and useful part which he had, for so many years, taken in the work of this Society, but also because of the valuable public services which he had rendered during the last thirty years of his life, particularly in the department of Sanitary Science.

As President of the Sanitary and Social Economy Section, I have undertaken the duty, which I esteem an honour, of putting the facts of his life in such a form as may be suitable for publication and preservation in our records.

Dr. Andrew Fergus was born in Newcastle on 12th May, 1822. His father and mother were natives of Kirkintilloch, and were both descendants of a good old stock of Scottish yeoman farmers. His father became a clergyman of the Church of Scotland. After having held various charges in Scotland he was called to be minister of the Presbyterian Church in Newcastle. He had a numerous family. The subject of our memoir, who was a younger son, was born after the removal of the family to the new charge in England, where they remained until the death of his father.

Our late fellow-member began his medical education at a very early age. At 14 years of age he went to London, and became a pupil with his brother, who had charge of a parochial hospital there. His medical classes were taken first in King's College, London; but on the death of his father, which occurred during his student years, his mother removed to Glasgow, and so he came to complete his studies at the Glasgow University. In 1845 he went back to London, and having passed the usual examination, he became a member of the Royal College of Surgeons of England.

His health had suffered during his studentship, and on that account he became a ship's surgeon, and continued so for two years. Part of that time he spent in the Arctic regions as surgeon to a whaling ship. In 1847 he returned to Glasgow, and having obtained an appointment as parochial surgeon to the Anderston district, he settled down to hard work as a general practitioner. His district at that time contained some of the worst household property in Glasgow, and so there, almost at the very beginning of his career, he was brought face to face with the study of insanitary conditions and their terrible results. In those days typhus and other fevers raged as an almost continuous epidemic in the insanitary back courts and slums of Glasgow. In the second year of his practice there broke out the great cholera epidemic of 1848, which continued without abatement for four months, and caused nearly 4,000 deaths in the city districts. The large experience which Dr. Fergus gained in the treatment of cholera during this epidemic led him to form the following opinions:—1st. That, in this climate, the choleraic seizure is always preceded by premonitory and generally painless diarrhoea; 2nd. That if these premonitory symptoms are properly treated the disease can be arrested; 3rd. That in the premonitory stage opium in full doses is an infallible specific remedy for cholera. In 1854, when cholera again broke out with epidemic violence, Dr. Fergus was still at his post of observation as district surgeon; and now we get an interesting glimpse of him as a practical sanitarian. I quote from a pamphlet on cholera which he published in 1866. He says:—

“When the disease returned in 1854, I put my former experience to the test. I warned everyone who consulted me as to what was really the first symptom or stage of cholera, and how to treat it, and *in no case* where my instructions were followed out did the ailment go beyond diarrhoea. My views were tested by the performance of an experiment on a very large scale. A man

employed in one of the largest engineering establishments in this city was at his work till mid-day, and dead by eight o'clock the same evening. This caused a great panic among the rest of the workmen. One of the foremen, who had lost his wife in the epidemic of 1848, had afterwards adopted my instructions, and had kept his family free from cholera, and he now applied to me as to what was to be done with his men. I reminded him of his own experience in 1848, and advised his giving them the benefit of it. He went away, but presently returned with several of the other foremen. They said the men were so terror-stricken that they could make no impression on them, so they had come as a deputation to see if I would go down and speak to them. This, after some hesitation, I agreed to do. I told them, if they were living temperately, both in eating and drinking, there was no reason why they should not continue their usual diet. To abstain from certain articles of ordinary food would only increase the feeling of fear by keeping the matter always in mind. I told them the disease was not a sudden one, knocking them down, as they expressed it, but that it gave ample notice; and I warned them to attend to the slightest relaxation of the bowels, adding, that there was more danger when there was less pain. I said they might take any of the other drugs they saw recommended in the newspapers, but that to each dose they must add one teaspoonful of laudanum; that each of the foremen should be provided with this medicine; and that as soon as the slightest diarrhoea occurred among the men, they were to get a dose, go home to bed immediately, and remain there two or three days. I said, moreover, that if one dose did not check the ailment they were to take a second, and a third if necessary, and to procure medical attendance without delay—these directions being no substitute for that, but merely to be of use to them and to their families in the first emergency. Next morning Mr. H., the foreman, called. He said, your short address last night has wrought like a charm; the men are all cheerful and active to-day; they feared the cholera as an unseen enemy to knock them hopelessly down. Now they see there is hope and power of prevention. In fact, the address has done so much good that we are anxious that you should speak to the men in our other work. I did so, and the result was that from that time in January till the end of May, *of 250 men who took diarrhoea, and were treated by the foreman, not one case went on to cholera.*"

I will not in this paper criticise the views expressed here so strongly by Dr. Fergus. In the year 1865 he brought these facts and opinions forward at a discussion on cholera in the Medico-Chirurgical Society of this city. At that meeting the treatment which he advocated was approved off by the majority of the physicians who had had experience of the treatment of cholera in these epidemics.

A few years after the subsidence of the cholera epidemic of 1854, Dr. Fergus had his attention called to the causation and prevention of other forms of epidemic diseases, in the following striking manner :—He lived at that time in the middle flat of a tenement in St. Vincent Street. The person who occupied the flat below had two cases of typhoid fever in his family, which Dr. Fergus was called to attend. At that time he was troubled with very bad smells in his own house, his water-closet, and also in the room above that occupied by the typhoid patients. Being afraid of the disease spreading to his own family, he called in a plumber and had his water-closet inspected. He superintended the operations of the workman, and found that the smells were issuing from ragged holes in the soil-pipe underneath his water-closet. He also found that the soil-pipe was very much decayed all round these apertures, and it occurred to his mind that this condition might be common in old houses, and might have some connection with the prevalence of disease there. So strongly did this idea take possession of his mind that he could scarcely sleep that night for thinking of it as a discovery of great importance. From that time forward, in every case in which he was called to attend upon typhoid fever patients, he insisted on an examination of the soil-pipe ; and this examination generally resulted in the detection of holes and ragged perforations. Observation and reflection led him to form these opinions :—(1) That these perforations were caused by the action of the sewage gases ; and (2) that the sewage gases entering dwellings by such apertures were not only important factors in the deterioration of the health of their inmates, but also active agents in producing such diseases as typhoid fever, cholera, diphtheria, scarlet fever, diarrhoea, and phthisis.

After some years of observation, he promulgated his theories on this subject at a meeting of the Medico-Chirurgical Society of Glasgow, held in October, 1868. The importance of his discovery was not appreciated by that meeting, and his theory of the

connection between soil-pipe perforations and the occurrence of specific diseases was looked upon with disfavour and incredulity. Dr. Fergus was in earnest, and was not to be put down by unfavourable criticism. He brought forward papers on the same subject, and reaffirmed his opinions at the Social Science Congress held in Newcastle in 1870, at the Social Science Congress held in Leeds in 1871, and at the Medico-Chirurgical Society of Edinburgh in 1872. At these meetings he exhibited an accumulating store of decayed soil-pipes taken from houses in which he had attended cases of epidemic disease, and in which he attributed the occurrence of the disease to sewer-gas admitted by these perforations. The serious attack of typhoid fever from which the Prince of Wales suffered in January, 1872, connected as it was in the public mind with the disgraceful conditions of the drainage and sewer connections of the house in which it was supposed that he had contracted the disease, was the turning-point in the tide both of professional and of popular opinion as to the theories publicly promulgated during the four previous years by Dr. Fergus. From that time his opinions as to the evil influence of sewage gases on the public health and their relationship to the outbreak of epidemic diseases were adopted and endorsed by the leaders of medical opinion in this country.

I have on several occasions brought before this Society my reasons for holding the opinion that the sewer-gas theory of the origin of such diseases as typhoid fever and diphtheria has been carried too far. In view of what modern investigation has taught us as to the specific and particulate nature of the contagium of such diseases, and in view of the discoveries which have been made as to the numerous media by which their germs may be carried from the sick to the healthy, the sewer-gas theory has undergone modification, and in my opinion will undergo greater modification still. But the fact that the presence of gases from decomposing sewage in the atmosphere of our dwellings is prejudicial to health will never be denied. To Dr. Fergus, more than to any other man, is due the credit of arousing public attention to the manifold defects of our water-closets and house-drains, which permit of such dangerous contamination of the air of our dwellings. To his influence we may also trace the institution of the sanitary associations of our large towns—associations which are doing such a great work in the detection, and in the remedy of the defects to which Dr. Fergus so forcibly drew

public attention. For these services his name will remain in the annals of sanitary science as that of a public benefactor—as the name of a man who has done a work in the cause of public health which ranks as one of national importance.

Dr. Fergus was elected a member of the Glasgow Philosophical Society in 1869. It is interesting to note that at the time of his admission to our membership the subject under discussion was the “Sewage Question.” The first three meetings of the session were devoted to this question, which was a burning one in Glasgow at that time. Dr. Fergus took part in the adjourned discussion on the evening of his admission. At the same meeting a deputation appeared before the council of the Society from the Glasgow Sewage Association with the proposal to join the Philosophical Society as a Section of Sanitary and Social Economy. This proposal was accepted by the Society, and Dr. Fergus, who had been a leading member of the Sewage Association, became the first Vice-President of the Sanitary and Social Economy Section. The names of the first office-bearers of the Section will be read with interest by the members :—

President:

Mr. CHARLES RANDOLPH.

Vice-Presidents:

ANDREW FERGUS, M.D.

Mr. W. R. W. SMITH.

Secretary:

Mr. D. G. HOEY.

Ordinary Members of Committee:

Messrs. THOMAS HOEY.

JAMES ANDERSON.

JAMES DEAS, C.E.

ROBERT LEGGAT.

Mr. WILLIAM M'ADAM.

COUNCILLOR MATHIESON.

BAILIE MURRELES.

Mr. SIGISMUND SCHUMAN.

COUNCILLOR URE.

In 1872 Dr. Fergus became President of the Section, and delivered an inaugural address on “Private Bill Legislation: its Evils and Remedies.” In 1873 he again addressed the section on “The Sanitary Solution of the Sewage Question.” This address he illustrated by certain experiments which showed that in water-traps some of the gases of sewer air are absorbed by the water on the sewer side of the trap, and discharged by the house end of it. The address, which is of great interest, was afterwards printed in the *Edinburgh Medical Journal* for February, 1874. At the expiry of his term of office as President of the Sanitary and

Social Economy Section in 1874, he was elected Vice-President of the parent Society. As showing the interest he took in our proceedings, it may be noted that in the absence of Sir William Thomson, the President, Dr. Fergus presided at all the meetings of the Society held that session, with one exception. In 1877 he was elected President of the Society, and in 1879 he delivered an opening address on "State and Preventive Medicine," in which he dealt with the history of Leprosy in the Middle Ages, and gave an account of the early history of vaccination and of its influence in arresting the prevalence of smallpox in this country. In 1880 he again delivered an opening address, entitled "A Sketch of the Early Years of the Society." These addresses were afterwards published in the *Proceedings* of the Society.

I shall conclude this brief and imperfect notice of his published addresses by two short extracts from his last address, by which, though dead, he may yet speak to us. Referring to a paper entitled "Prevention of Smoak," which was read at this Society in 1803, Dr. Fergus says:—"This question is much more clamant now, and in Glasgow it has been most shamefully neglected—by the authorities, I would say, shamelessly so. I hope you will bear with me when I say that the smoke nuisance is a reproach and a disgrace to a city like this, so full of mechanical skill and ingenuity. Its effect on the health is injurious, and it is hurtful in another way, inasmuch as we have become so deadened to its offensiveness in an æsthetic point of view that not a single protest is raised against the foul pollution of the beautiful Firth of Clyde during the summer months. I believe that all offensive smoke can be consumed; that steamboats can do so is abundantly proved by seeing them emit only a little colourless vapour when they are in harbour. As soon as they leave it, however, all restraint is at an end, and the various summer resorts are polluted by their dense black smoke as they pass them in turn. During calm weather it is really melancholy to see how the beauties of nature are veiled by the clouds of smoke which, layer upon layer, roll from successive steamers."

I finish my quotations by another extract from the same address, which shows our late President in another phase—the genial, happy, humorous phase, so characteristic of him, and with which those who knew him well were so familiar:—"I find," he says, "that on May 12th, 1806, a present felt want was supplied. 'It was then moved that a footstool be provided for the

President's chair, which was carried, and a card wrote to Mr. Watt to make one accordingly.' Now, when I first had the honour of occupying this chair it was so much more elevated than any I had ever sat in before, that, as my feet did not nearly reach the floor, I had some difficulty in keeping my seat. On applying to the librarian, he kindly provided me with an old packing-box, by the aid of which I have been able to get on with comfort if not with dignity. I humbly submit it to the furnishing committee whether the motion alluded to above might not with great propriety be revived in favour of all future Presidents."

During the years that Dr. Fergus occupied the President's chair the Society prospered greatly, and during that time much extra labour was put upon the office-bearers by its incorporation under the Companies' Acts, and by the building of the premises which we now occupy. To the arrangement and carrying out of this work Dr. Fergus devoted a great deal of time and thought. He was rarely absent from any meeting, and I think you will bear me out in saying that no man ever occupied the chair of this Society with greater efficiency and general acceptance. When he retired from office, a well-earned vote of thanks was awarded to him by acclamation, for the able and zealous manner in which he had discharged his duties. Outside of this Society his life was full of occupations. How he found time to overtake all his multifarious engagements, and attend to the calls of a busy practice as a well-employed physician, remains an unsolved problem to many of his friends. It is another illustration of the old observation that the busiest men do most work for the public outside of their own business. The capacity for work grows with the exercise of the capacity. In the time left at my disposal, I can only give you a hurried catalogue of his more important public duties. His great interest in, and knowledge of, sanitary matters was the principal factor in determining the direction of his public work. In 1870 he was induced by some gentlemen, who were interested in the sanitary improvement of the City, to enter the Town Council as representative of the ward in which he lived. During his three years' term of office as a Town Councillor he took an active part in the meetings of the Health Committee, and he initiated several sanitary inquiries which have been of great public utility. In 1874 he was elected President of the Faculty of Physicians and Surgeons of Glasgow,

and in that capacity he performed his duties with such diligence and acceptance that he was twice re-elected, an honour rarely bestowed on any man in the long history of that ancient Incorporation. When the Social Science Congress came to Glasgow in 1874 he acted as one of the local secretaries, and by request opened a discussion on the disposal of sewage in the Health Section. He acted as one of the treasurers to the British Association for the Advancement of Science when it held its meeting in Glasgow in 1876. In 1877 he received the appointment of Crown representative for Scotland in the General Medical Council, in room of Sir Joseph Lister, and continued to attend its meetings in London during a ten years' tenure of office. He was an active supporter of the Glasgow Science Lectures Association, and he delivered the address on Public Medicine at the meeting of the British Medical Association held in Cork in 1879. He took an active interest in almost every charitable and philanthropic institution. In particular, he was a much-valued member of the Board of Management of the Royal Infirmary, of the Western Infirmary, and of the Eye Infirmary. For many years he was a Manager of Anderson's College, and latterly he was Chairman of the Managers of that Institution, and took a warm interest in the scheme for the formation of a Technical College in Glasgow.

In every position which he occupied he did his work conscientiously and well. He was never a very robust man, and such a strain of continuous work was sure to tell on his health. For some time before his last illness he had spoken of his life as a weary fight with bodily weakness, and thought of retiring from practice, so that he might enjoy a few years of rest and quiet before the end came. But it was not to be. On the 18th of July he was seized with a sudden attack of pain in his chest, which developed into a pleuro-pneumonia. After ten days of suffering, borne with characteristic courage and patience, he died on the 29th of July, aged 65.

When we consider his ability, his readiness to help any one who needed and asked his assistance, his continual and unselfish labours in the public interest, and the genial, kindly, courteous manner of the man, we can understand the universal feeling of grief with which the news of his death was received by all classes of the community. He has left behind him a nobler legacy than wealth or fame—the example of an honest, industrious, and self-sacrificing life.

XIII.—*On the Spread of Enteric Fever and, possibly, Diphtheria, in Rural Districts by the use of City Manure for Agricultural Purposes.* By DAVID PRYDE, M.D., Neilston.

[Abstract of Paper read before the Society, 4th April, 1888.]

THE object of the paper, of which the following is a short abstract, was to prove the connection between the outbreak of enteric fever in country districts and the use of city manure spread on the fields immediately surrounding the open streams which constitute the water supply of the farmers and others. A number of enteric cases were related which had occurred in the author's neighbourhood, a hilly and healthy district, within the last few years, where the only circumstance common to all the cases was the fact that the water supply of the people had been brought under the poisoning influence of city manure at its source. Plans and sketches were submitted with the paper showing the relation of the hill slopes from which the water was collected to the individual outbreaks. It was shown (1) that in every outbreak the results were conformable in theory to the known laws of zymotic contagia; (2) that the severity of the cases was in the ratio of the concentration of the virus to the water supply; (3) that where the water was scarce and the virus least diluted the cases from the first were severe, while in cases where the volume of water was never so scarce and the virus presumably more diluted the attacks were milder and more benign throughout.

From the author's knowledge of the lie of the land, the trend of the water channels, and the relation of the manure to the open streams, he looked upon the manure as the *fons et origo* of all the evil; in point of fact, in the author's opinion, every waggon of this manure sold for agricultural purposes and sent out into the country around the city, carries with it the slumbering potentialities of many fresh outbreaks of enteric disease which may spring into activity at any time where, through the medium of some water supply, the germs in sufficient quantity reach a suitable soil in the human body. The author contended that enteric germs are

by this means kept in constant circulation between the city and the rural districts surrounding it. The manure is fed directly with fever germs in the fever-breeding centres of the city; it is collected and sold to the farmer and taken to the country; by him it is spread broadcast over the fields, where it is exposed to the carrying influence of rains, and gets washed into the streams whence, in many instances, farmers derive their only water supply. Here it springs into sporadic activity in the farmer's family circle, and then follows the probable danger of the germs completing the cycle by being taken from the farm back to the city in milk, again to develop fresh epidemics in the centre of its primary origin.

As regards the relation of diphtheria and enteric fever, Dr. Russell in his presidential address makes the following remark—"Regarding our cities we may conceive of three zones of incidences—an outer wide-encircling zone of rural districts most affected; a middle zone, the suburbs and better residential parts of the city, less affected; and an inner zone, the centre of the city where the poor and squalid reside, which is least of all affected." No reason is assigned for this, no explanation offered; and when the many advantages which those living in rural districts enjoy are considered, such as atmospheric surroundings, sparseness of population, healthiness of occupation, one would have been inclined *a priori* to expect that the opposite of this should be the case. But accepting the fact as stated, and the expression no doubt formulates the outcome of a vast amount of experience, the author held that the reason for it was to be found in the fact that the wide-encircling zone of rural districts was the identical zone round the city to which the great bulk of the city manure was sold for agricultural purposes.

The author went on to remark:—In a contribution upon the etiology of diphtheria made to the French Academy of Sciences, 6th June, 1887, M. Teissier says, as the result of his studies of contagious maladies, that the germs of diphtheria are abundant in manure heaps, from which they rise into the atmospheric dust, to be absorbed especially by the respiratory organs, and that manure heaps constitute excellent media for developing and conveying this pathogenic germ. Here, again, there was a reason for enteric fever and diphtheria associating together and conforming to the same law, namely, that of being found most abundant in the zone of rural districts round the city. It was the identical zone in which the city manure was chiefly distributed, and the author held

that it was strongly suspicious that in both instances the carrier was the same. In point of fact, the deliverance of M. Teissier was an *experimentum crucis* developing the other side of the argument. It was of course unnecessary to say, if the germs were found in manure heaps, as pointed out by this writer, and liable to be raised in dry weather into the atmosphere as dust, they were equally liable, when spread out with the manure over the farmer's fields, to be washed by the rains into the streams, thence to reach many a family in rural districts, just as, in the author's opinion, enteric germs were spread, and constitute an additional reason against the sale of this manure for agricultural uses. To summarize:—On the authority of Dr. Russell, we have it that enteric fever and diphtheria prevail out of all proportion in rural districts; and on the authority of M. Teissier, that diphtheric germs are developed in manure, which is one of their best carriers; and there is the further very important fact that it is to rural districts round the city that this manure is chiefly, if not altogether, sent. These facts stand out boldly in relation, the author thinks, of cause and effect, and steps should be taken to prevent this manure being spread on the gathering grounds of water supply. The money value of the manure to the municipal authorities the writer had no knowledge of, but he was certain that its value could not for a moment be placed in comparison with the value of the lives jeopardised, possibly sacrificed, by its being sown broadcast over the farms which for miles surround the city; and he suggested that the proper thing would be its destruction in some kind of charring furnace under the control of the cleansing department of the city.

XIV.—*Some Important Points in the Sanitary Work of a Great City.* By PETER FYFE, Sanitary Inspector, Glasgow.

[Read before the Society, 11th April, 1888.]

PERHAPS there is little work done beneath the sun which involves for its thorough prosecution a more varied knowledge and experience than sanitary work in a great city. Its all-embracing demands comprehend the skill of the pathologist, the biologist, the chemist, the architect, and the civil and mechanical engineer. The best efforts of all these scientists ought to be enlisted by the practical sanitarian, and he must add to the knowledge which he can utilise from their researches a knowledge of the law in health matters.

Theoretically, the first duty of a sanitarian who has any responsibility officially in a city is to think and act with a view to the total exclusion of every material from which contagion or infection is to be apprehended. Like Professor Tyndall on the heights of the Sparrenhorn, with his sterilised infusions of beef, mackerel, turnip, and fowl, exposed to the actinic rays of the Alpine sun (which Dr. Bastian believed to be capable of promoting spontaneous generation), the scientific sanitarian of to-day does not believe that a specific infectious disease can arise *de novo*, and would like to make his first and greatest concern the total prevention of any influx of specific contagia from without. Unfortunately in every large city the specific germs of disease have already gained an abundant entrance, and they find among its inhabitants, its homes, and its detritus, the pabulum wherein they may increase and multiply. The greater part of his work on this account becomes, therefore, palliative and curative in its nature, instead of being preventive. This work may be classed under three main heads, namely:—

1. When contagious or infectious disease does break out, he must endeavour to arrest it before it can spread to any extent.

2. He must do all in his power to diminish the "nuisances," which may produce, and which always aggravate, an outbreak of disease.

3. He must control the conditions under which the poorer classes live with regard to proximity.

4. He has also the duty superadded of supervising as strictly as he may the food supplies of the community in order to prevent adulteration.

I said that, as a theory, the first consideration of a sanitarian ought to be the prevention of infection coming in from without. Like many other beautiful theories, this one, it seems, cannot be satisfactorily put into practice—mainly, I presume, from the fact that the legal restrictions necessary in order to carry it out would interfere with trade interests. So that actually what should be the *very first* duty of the city sanitarian becomes, through his sheer helplessness in the matter, the very last; and practically he finds himself trying to cure the epidemic which, for want of legal power, he can do little or nothing to prevent. Local Authorities in great cities, through no fault of their own, may be likened in this respect to the priests of whom Cowper says in *The Task*—

“ They whose office is, with zeal sincere,
To watch the fountain and preserve it clear,
Carelessly nod and sleep upon the brink,
While others poison what the flock must drink.”

Contagium may be, and is, conveyed into the midst of a community in many ways: by infected persons, by clothing, by rags, by hair, by water, by animal food, and by what to us in Glasgow is perhaps the most important of all—by milk.

It is to the last article, in this view of sanitary work, that I desire particularly to direct the attention of this Society. On the 20th of March, 1878 (just ten years ago), a report by our President, Dr. Russell, was sent to the then Lord Advocate (Mr. Watson), along with “Suggestions as to an Act for the Sanitary Regulations of Places of Milk Supply to Towns,” drafted by Sheriff Spens. Dr. Russell, in his report, clearly traced 166 cases of typhoid fever in the West-End of Glasgow to infected milk which had been obtained from a single dairy, and I do not think a year elapses which does not witness an outbreak of infectious disease in some quarter of this city from the milk supply. The principal proposed enactments embodied in Sheriff Spens’ “Suggestions” were:—

1. No farmer nor dairyman to be allowed to send milk into a city or town until his *premises* were passed by the Medical Officer and his name placed on the city’s or town’s register.

2. Every such farmer's or dairyman's premises to be subject to inspection at all reasonable times by the duly appointed officers of the town in which the milk is distributed, and regulations and bye-laws may be drawn up by the Medical Officer to which every such farmer or dairyman must conform.

3. Every farmer or dairyman must, within 12 hours of its becoming known to him, notify to the Local Authority of the town to which he sends his milk any case of contagious or infectious disease in his household, and, pending directions, suspend his supply of milk.

4. Each town's Local Authority to appoint a sufficient staff to carry out the work of supervision.

These valuable "Suggestions" fell to the ground, and instead of them we have the Privy Council Orders of 1885 anent dairies, cowsheds, and milkshops, and an amending act of 1886 transferring the application of these "Orders" from the Privy Council to the Board of Supervision (so far as Scotland is concerned), with this rider, "Provided always that no general or special order made by the Board of Supervision under this section shall be binding until it has been confirmed by the Secretary for Scotland."

In his circular of August 16th, 1886, to the various Local Authorities in Scotland, the Secretary to the Board of Supervision says:—"It is now an ascertained fact that disease is largely disseminated from dairies and milkshops where the sanitary arrangements are defective, and from which persons suffering from infectious disease have not been removed. There is no doubt, therefore, that the Statute imposes on the Local Authority a most important duty, which the Board trust will be duly discharged." In the first sentence he might quite truthfully have added *farms* to dairies and milkshops. The duty which Mr. Skelton speaks of is embodied in the dairies, cowsheds, and milkshops orders, and the bye-laws and regulations made under them by the various Local Authorities. This duty, if zealously and fairly discharged by each Local Authority in the country, would, humanly speaking, prevent many cases of disease and death in every great town. But this duty is not discharged, nor can any man expect it to be discharged in extended country districts where the individual on whom falls this responsibility receives the princely (?) remuneration of £5 per annum. The rural districts of Scotland are known to be quite devoid of proper sanitary supervision.

Dr. M'Vail, the Medical Officer of Kilmarnock, in a lecture on the new "Burgh Police and Health (Scotland) Bill," delivered before the Sanitary Association of Scotland last autumn, said—"The only parts of the country unprovided for will be those where educated public opinion is at a minimum, where ignorance most prevails, and where vested interests are most powerful." He went on to say—"From the milk supplied by a country dairy miles away, enteric fever or scarlatina may be imported into the heart of a city; and while the sanitation of the city may be beyond reproach, its inhabitants may see their children die by reason of the filth which prevails in another county."

Now when the word *may*, used by Dr. M'Vail in this sentence, can with truth be converted into the word *is*, it is surely high time that those in the forefront of sanitary matters in every town in Scotland should by united and determined effort seek to put an end to this state of things. It not only threatens the health and lives of those who are depending on us, but when outbreaks do occur they set "red ruin" on the track of the innocent city dairymen who unwittingly have dispensed the poisoned food broadcast among the inhabitants. Glasgow is supplied from the country with about 35,000 gallons of milk daily from 1,175 farms. Whenever any case of infectious disease occurs in a farm which supplies milk to the city, and becomes known to us, the farm is immediately inspected, a plan of it is carefully made to scale, and a report on it is made by the inspector and handed to the Medical Officer. If the report is of such a nature that the Medical Officer has good ground for believing that the milk is contaminated, we communicate with the dairyman who receives it, and warn him of the consequences which may follow if he continues to distribute it in the city. The Medical Officer or Sanitary Inspector of the district from which the suspected milk is sent is also communicated with, and often the Medical Officer of the city makes a personal inspection of the farm and the stock.

These measures in all likelihood serve to stop the further influx of the poison. But it is too late on many occasions. Already into the city is poured "the leprous distilment, whose effect holds such an enmity with blood of man, that swift as quicksilver, it courses through the natural gates and alleys of the body." It is the old story of "locking the stable door when the steed has been stolen."

In the first diagram (Fig. 1, Plate II.) you have a plan of a farm

in the country which regularly supplies milk to the city. The general filth around it, and its indifferent condition as a structure, I cannot, of course, show you; but I beg to call your attention to a few points in the arrangements which are defective.

The dwelling house, which lies between the two wings, consists of five apartments. The water supply (perhaps the most important matter to be considered with respect to a farm) is obtained from two dip wells, each about two feet deep. One is situated just outside the kitchen wall. It is fed by a drain pipe which is laid beneath the kitchen floor, and is led out into the field in front of the farm, from which in wet weather it collects its supply. This field at the time of the inspection was pretty well littered with cows' dung, and I do not doubt that in certain seasons the aroma of this excrement will be traceable in the well. The other dip well is dug at the west end of the farm, at the extreme left, just on the edge of the public road, but on a lower level than it, so that the surface water from the road finds free access to it, and becomes part of the domestic supply. These are all the arrangements which have been deemed necessary to water the steading.

Look at the next most important matter—namely, the situation of the milk house. Instead of being disconnected and isolated from the dwelling house, the scullery, and the byre, it was found to be in direct communication with the first two, and with the last through the scullery. It is, no doubt, a convenient arrangement in such farms when the mistress or maid or children can step through a short passage into the milk house from the kitchen and bedroom on the one side and from the byre on the other; but to my mind it quite destroys, in certain contingencies, any chance of the milk being kept free from contamination. It will be observed further, in looking at the plan, that all domestic washing and clothes-boiling must be done in the scullery, off which the milk house *immediately* enters.

Fig. 2 shows another farm where the milk house is in communication, through the boiler house, with the kitchen on the one hand and the byre on the other. The sewage from the boiler house runs directly into a large iron boiler situated just through the wall opposite the window, and the overflow from this iron cesspool is conveyed by a tile drain to a point in the stack-yard a little distance from a dip well, from which point it trickles past, in the form of a ditch, 6 feet from the well. There is

another well just outside the boiler house, in the garden, 30 feet deep, from which water is also supplied. Both of these wells, however, dry up in the summer time.

This is another farm, among hundreds, which is not provided with any washing house for domestic purposes, a common and serious omission when zymotic disease visits the place.

Now if such farms as I have just described (and they are unhappily far from uncommon) are allowed year after year, without any change in their physical circumstances, to send in milk among our citizens, we cannot expect to escape from infectious outbreaks from time to time.

With regard to the cattle which give the milk, and the possibility of scarlatinal virus proceeding directly into the milk from them, investigations are being made by Dr. Klein and other experts of the Local Government Board in England, and we may expect to learn shortly whether the micrococcus discovered in the ulcerated udder and teat of the cow has any etiological connection with scarlet fever in man. If such be the case, and if, as Dr. Koch says, "The relation between human and animal tuberculosis, particularly perlsucht, is a similar one," the responsibilities of all sanitary authorities in the matter of strict oversight of the milk and flesh alike of diseased cattle become very greatly increased. Well, towns' Local Authorities have at present neither power nor machinery. The new Burgh Police and Health Bill at present before Parliament provides for us no such central authority and medical and scientific inspectors as the sister country has possessed for years. Then, again, it is for burghs and populous places alone. The country is left to feed the towns from amid the insanitary conditions which, through ignorance and carelessness combined, many of its landlords or farmers will not remove.

In my opinion, the Sanitary Section of this Society (if it be not now too late) should not let the new Burgh Bill pass into law without presenting the Marquis of Lothian, Her Majesty's Secretary for Scotland, with an earnest memorial on similar lines to the one presented in the May of 1883 by this Society to the Earl of Rosebery.

I now pass on to consider, as briefly as I can, the three main paths of sanitary work which are traversed, or should be traversed, by every town's Local Authority. Towns, like individuals, are made wise by misfortune. Some one has likened infectious

disease to fire. Kindle it in a city, and so close and intimate are the conditions of life that its spread is certain if all the hydrants and hoses of the hygienic establishment are not fully used upon it at once.

The question our esteemed President asked in his memorable opening address, "What am I to do with my dirty neighbour?" is a pertinent one, and also a most difficult one, the main reason being that "the dirty neighbour" has various cogent reasons for his strong prejudices against any sanitary principle applicable to the extinction of disease being applied to him or his. These prejudices of his are the main barriers opposed to the immediate suppression of infectious disease when it first arises and becomes known. The first prejudice to be contended against is the most dangerous—namely, the desire to hide his trouble. He sees in the notification of his case to the sanitary authorities the removal or strict isolation of the patient who is dear to him; the prohibition of his other children from attending school for a time; the loss for some time of the use of his washing house; the fumigation of his house; the removal of the clothes, bed, and bedding; and the suspicion and avoidance of his neighbours. The immediate burden which a visitation of infectious trouble has laid upon him, blinds him, perhaps, for the time to the fair consideration of the case as it affects his neighbour, and in many instances his only desire and thought is to suffer in secret, and let the world take its chance.

This attitude of mind, easily understandable, is of course a constant menace to the general health; and in Glasgow and other large towns where medical notification is not in vogue, it has the effect of placing the officers, whose duty it is to deal with epidemic disease, on detective duty, which to do effectually in the city would involve the keeping of a staff equal in numbers to our police force.

Fortunately, our medical practitioners have given to those charged here with health administration great assistance voluntarily, and as the proposed new Burgh Bill makes medical notification compulsory, this difficulty is in a fair way of being swept away.

But while we may congratulate ourselves on this prospect, we must at the same time acknowledge the responsibility it throws upon us. Other difficulties, which have to be contended with more or less at present, will be considerably augmented, especially

at first. Removal to hospital, which at present is often difficult and sometimes impossible, on account of human affection in ignorant people, will not only be increased, but the widely-differing difficulty may arise of want of hospital accommodation.

Then, again, the work of disinfection will be increased in a corresponding ratio—in fact, the whole of the operations which have been introduced by sanitary science must be brought into full play, if this compulsory medical notification is to be anything but a mere name. To break down the natural aversion of many to send their cases to hospital, we must always rely on the kind and unselfish advice of the medical practitioner.

His influence with the people who call him in is great, and the administration of the law in this part of health work appears so harsh and inhumane, that every assistance in this direction from him is of inestimable value.

Regarding the science of disinfection I would offer some remarks.

Practical disinfection, or, in other words, the work which in practice can be accomplished in order to destroy all life both in the disease germ and in its spore, or egg, can easily be explained and followed. It includes fumigation and cleansing of the infected apartment or house, the thorough boiling and washing of all washable clothing and other articles, and the treatment under steam, hot air, a solution, or a fumigant of every unwashable article.

With regard to the first—namely, the disinfection of the dwelling, little need be said, as, scientifically speaking, it cannot in practice be done. After a large number of experiments had been carried out by Dr. Koch, with sulphurous acid in proportions varying from .12 to 10.56 per cent. volume, both in an air-tight chamber and in an ordinary room, he sums up his observations by saying, "These results show that, for purposes of practical disinfection—sulphurous acid is useless."

Drs. Fischer and Proskauer, after a series of experiments with chlorine gas in a cellar, previously saturated for two hours with the vapour of water, sum up by saying—"Complete disinfection of rooms appears therefore to be unattainable by means of chlorine, owing partly to its slight power of penetration into crevices and fabrics." With respect to bromine they found that even with the small volume of one-fifth per cent, the woodwork and the paper were stained, the woollen, cotton, and linen fabrics left in the

apartment were discoloured, and the inequality of diffusion is a grave objection to its use as a disinfectant.

In the face of these, the latest scientific deductions on the subject of aerial disinfection, it might be thought a reasonable proceeding to cease from further expenditure of public money in this direction, and allow the simple cleansing and airing of the infected apartments to work in a natural way in eliminating the contagia. I hardly think so. Amid a varied city population many persons are found whose habits are, unfortunately, not of a cleanly order. Our estimates of the effect of fumigation in the houses of such may not be based on scientific deduction, but elements do come into play in the minds of the people which render the operation beneficial.

When speaking of science as the grand destroyer of finalities in everything, Emerson remarks that, "with such volatile elements to work in, 'tis no wonder if our estimates are loose and flowing. We must work and affirm, but we have no guess of the value of what we say or do." So I cannot point out to you in set terms the value of this part of sanitary work, but yet I am convinced that it has a value both in causing a general cleansing in the infected area, and also by creating in the public mind a sense of security. I daresay all of us have some experience of the power of the imagination. I exhibit here our new safety fumigating pans.

In the second part of this work—namely, the disinfection of all articles which can be conveyed to a disinfecting establishment, we stand on inexpugnable ground. In view of this part of the subject I have prepared the plan shown on Fig. 3, which is an improved copy of the city works at Belvidere. In every large town such an establishment is absolutely essential if the people are to be prevented from sending infected articles to the public laundries or the washing-house, or from trying to treat them in their own homes.

With an estimated population in Glasgow of 538,128, we get 1,000 infected articles per average day to wash and disinfect. In the majority of cases the collecting and purifying work involved in this has to be completed within the compass of 18 hours, as the poverty of many does not permit a longer retention of the goods. Regarding the treatment of those articles, I would direct your attention for a minute or two to Fig. 3, and to one or two of the methods which ought, in my

opinion, to be adopted. As the bundles containing the articles come in, they should be thrown to the right or left of the inner entrance, B B, according to their capability of being washed or not. To the right, it will be observed, a rectangular reception chamber, C C, is placed. In this chamber each bundle should be placed, as it comes in, and untied. The chamber is arranged to hold easily as many bundles of clothing as are daily sent in, each of which is known to contain about 60 articles on the average. The iron bogie from the hydraulic press is then brought forward, and the contents of a bundle are put into it. A solution of bichloride of mercury of 1 in 10,000 is then run down upon them from a small cock attached by a flexible hose to a shallow tank placed above. The bogie is then run on to the head of the press, which is then set in motion, and slowly travels up towards the butt attached to the top of the press, which is made to fit into the bogie. The solution is thus pressed through the clothing, which at the end of the stroke lies at the bottom of the bogie thoroughly saturated, and quite dry enough to be immediately wheeled into the ticketing room, where, after lying for half-an-hour, the women begin work upon it. Bichloride of mercury has been discovered to be by far the most potent destroyer of germ life when used in solution. Dr. Koch says that a solution of 1 in 20,000 volumes of water destroys the spores of anthrax in ten minutes. Dr. Klein, of the Local Government Board, has, however, found that the sporeless bacilli (*subtilis*) were not destroyed after being exposed in this strength of solution for half-an-hour. Exposure during this time in a 1-in-10,000 solution was, however, found to be quite effective.

This preliminary destruction of any infective organised matter, before the articles pass into the hands of the operatives for ticketing and washing, serves a most important purpose—namely, to prevent infection spreading among them, and also to prevent any infective matter being taken by them into their families or among the people of the city where they dwell.

In the case of such diseases as smallpox and typhus it is almost essential to have some such immediate destructive agent employed. I find among the hands (about 20) who have been employed from year to year in our disinfecting work during the last 20 years, that ten of them, five men and five women, have been struck down and have died of typhus fever, and in the families of two of them four

persons were seized with the same fever, but recovered. Of course, I cannot say they met their death through handling the poisoned clothing or bedding, but yet I do not think such clothing or bedding should be placed in their hands fresh from the patient until some such simple method as I have described has been employed in order to lessen the danger of infection. In order to be assured that this solution could not in any way damage the finest fabrics, I took samples of various coloured silks, white cotton, cotton sprinkled with blood, coloured handkerchiefs, pieces of blanket, and feathers, and steeped them for three hours in the solution. The solution which was used was not acidified by hydrochloric or tartaric acid, nor was muriate of ammonia used in order to make the salt more soluble. It may be advisable in practice to use such solvents, as the antiseptic power of corrosive sublimate is reduced whenever it comes in contact with albuminous substances. They were dried naturally and minutely examined under a magnifying glass. No change could be observed, nor could any precipitation of the salt be seen. Minute traces of the salt would doubtless remain in the goods, but, as Dr. Koch says, "they would be absolutely harmless;" besides, after the ticketing process has been gone through, they immediately pass on to the boiling, washing, and drying processes. I need not describe these, as they are the ordinary methods of the wash-tub, assisted by steam and machinery.

Let us return for a moment to the entrance. On the left hand there is a compartment, A A in plan, into which beds, bolsters, pillows, and all unwashable articles except carpets are thrown. After being sorted and marked they are duly set into the travelling iron bogie and wheeled into one of the steam disinfectors.

There they are exposed to the influence of steam at 7 lbs. pressure (giving a temperature of 234° F.) for one hour. This has been found by experimentalists sufficient to destroy the spores of anthrax placed in the centre of a roll of flannel. In consideration of the fact that some towns and burghs both here and in England are still using hot-air apparatus for this class of goods, I would like to draw attention to the marked contrast which is drawn by Koch between this method and steam. He says, "With hot air, *four hours'* exposure to a temperature of 266° F. to 284° F. only brought the internal temperature of a small roll of flannel to 181° F., and in no way impaired the vitality of spores of bacilli placed at the centre, while exposure to steam at

248° F., for *one and a-half hours*, raised the internal temperature to 242° F., and killed the spores. Even one hour at 230° F. sufficed to raise the temperature to 205° and to destroy anthrax spores placed there. It is plain, therefore," he continues, "that steam acts much more powerfully than hot air, and penetrates porous objects more rapidly and deeply." Science, then, has thus given us the death-line of the most resistant spores, both by solutions and by steam treatment, and both are within the range of every-day practice for all that a city can give us day by day. It only now remains for each sanitary authority to use the means.

All that we can well do with carpets, without injuring them, is to beat them thoroughly, air them, and send them home.

There is another aspect in which we may view the "dirty neighbour"—namely, under that condition of uncleanness, or unwholesomeness, which may bring disease into his household, and so into the households of others. When such a condition exists it is called a "nuisance." The word "nuisance" covers a multitude of sanitary sins, such a multitude, in fact, that I would not enumerate them even if I could.

Only one point of interest and novelty, in the range of nuisance detection, do I wish to bring before the Society. This is a new smoke-testing apparatus. I daresay it is known to most of you that all such machines hitherto have been wrought by hand. This method, besides occupying the whole time of an operator, does not give the constant velocity and pressure which, especially during windy weather, are found necessary in order to overcome contrary currents in the drains and pipes. It has not unfrequently happened, in certain complicated systems of drainage, and in windy weather, that a whole day has been spent in the vain endeavour to discover the source of a nuisance by the smoke-test.

Now, with the small and compact machine before you, the work of testing can be done in about half the time formerly occupied, without the assistance of a driver and with surer results.

The speed and pressure, of course, depend on the water pressure which can be got from the house connections. In Glasgow, where a pressure of 50 lbs. per square inch can be obtained, a constant air speed of 2,500 feet per minute is attained with a small fan six inches in diameter. This speed yields a pressure at the nozzle of the machine of $\frac{3}{4}$ inch of water, which can hardly be maintained, however, in the drains and soil-pipes

where the pressure registered has been found to be $\frac{1}{2}$ inch of water, equal to 2.6 lbs. per square foot. This is the pressure exercised by a gale travelling at the rate of 25 miles an hour. Thus, both by pressure and steadiness of volume, we can now combat troublesome drain currents satisfactorily. Some remarks have been made in the city to the effect that we are apt to put too great pressure on for some water seals or traps to withstand. This will be seen by the foregoing to be a fallacy. Every trap should have a water lock of $1\frac{1}{2}$ inches at least, or three times more than can be lifted by the fans in use, and plumbers now are making them considerably deeper than this. The depth of the seal in a trap is an important feature in drainage, as I have found by experiment that in a temperature of 60° F., containing, according to hygroscopic measurement, about 4 grains of moisture to the cubic foot (which figures may be taken to represent the average temperature and moisture of normal air during the summer months in this latitude), the evaporation of water from an exposed surface of from 2 to 4 inches diameter is $\frac{3}{4}$ inch in 18 days. This means that a water seal $1\frac{1}{2}$ inches deep would be destroyed in 36 days. When we consider the length of time during which people resort to the coast or country in the summer, it is apparent that long before the return of many of them, all the ordinary house traps will have been unlocked, leaving the dwellings exposed to contamination from the drainage system if the various basins, baths, sinks, and water-closets remain unused during this period.

What bearing this fact may have on the general health of the returning inmates I am not prepared to say, but I think no one will venture to assert that it can have no evil effect whatever.

A novel feature has been introduced in this latest smoke-testing apparatus, which becomes especially valuable in testing new drains, or in testing such drains as are inaccessible for want of a suitable grating or a ventilating trap in connection with the system. This consists of a small air-injector attached to the casing and working through the fan. By simply opening a pet cock a jet of water is introduced. This induces an air current which can be passed into the drain at a pressure of 7 inches of water. This is equal to $36\frac{1}{2}$ lbs. on the square foot, and represents the force of a great hurricane.

By this simple means we shall in future be able, not only to force the smoke against the most violent currents, but also to

break through any obstructions which may be set up by unknown common traps or tongued cesspools. The injector can also be used as an aspirator, by means of which the air of any place or room can be stored up, or drawn through water or any other liquid for testing purposes.

Regarding the third section of a sanitarian's work—namely, the control of the poorer classes with respect to the proximity in which they dwell, a momentous problem is put before us for solution. What is to be done for the people who are condemned to live in such conditions as are pictured by the words "348 to the acre"? In some districts of our city, as pointed out by our President in his admirable lecture on "Life in One Room," delivered in February last to the Park Church Literary Institute, such a state of things goes on from day to day. Nay, within this close environment during the night are found, like the zœglia of bacterial life, little knots of humanity taking their repose at the rate of 4,400 to the acre, or 10 persons in 11 square yards. There are 23,030 ticketed houses in Glasgow, of which 16,413 are single apartments. A ticketed house means that it contains less than 2,000 cubic feet of air space, and of the 16,413 ticketed single apartments, 3,285 contain less than 900 cubic feet of air space.

For the purpose of being able to give you some idea of the atmosphere in which many of our population nightly sleep, I caused two samples of air to be taken for analysis.

No. 1 was got at 3.40 a.m. on Monday last from a one-apartment house on the South-Side measuring 700 cubic feet. Four adults and three children were found sleeping in it, which gave each individual 100 cubic feet to breathe in. The amount of carbonic acid gas was certified by Dr. Wallace to be 21.9 in 10,000 volumes of air.

No. 2 was taken on Friday last at 3.45 a.m. in a one-apartment house measured for $3\frac{1}{2}$ adult persons, and containing 1,075 cubic feet. Seven adult persons were found in it. The carbonic acid gas in this sample was 14.1 in 10,000 volumes.

It requires to be noted, in connection with these figures, that they represent almost altogether pollution from the human body, and almost nothing from gas or lamp flames.

The carbonic acid gas is therefore, in the first sample, $5\frac{1}{2}$ times what it should be, and $3\frac{1}{2}$ times in the second sample.

The normal quantity of carbonic acid gas in ordinary city air has been found to be 4 in 10,000 volumes. Six volumes of carbonic

acid gas in 10,000 is said by authorities to be unfit for breathing. Now, what can the sanitarian, with the low limit of 300 cubic feet of air space for each adult, do to decrease the chances of disease and low vitality which certainly surround such human homes. The wretched people who are found from time to time sleeping under conditions which the law does not sanction are every week brought into the police courts; but their woe-begone and miserable plight makes it difficult for the magistrates to fine them or send them to prison. Doubtless those who have brought their misfortunes upon themselves and their families through drunken and degraded habits (and I am afraid I must say their name is Legion) ought to be steadfastly prosecuted; but many cases of distressing and real poverty are so inextricably mixed up with such that it is almost impossible to make a distinction legally.

By constant supervision much has been done and is being done to repress overcrowding and improve those lowly dwellings; but the health of Glasgow will never be what it ought to be until the law against unrighteous occupancy of single-apartment houses is revised and improved. It is not, in my opinion, sufficient, in regulating the occupancy of such dwellings, to lay down a law which causes a ticket to be placed upon the door intimating the number of cubic feet and the number of occupants allowed. This only permits the worst form of occupancy—namely, where lodgers are taken in either for purposes of gain or otherwise. A new law ought to be passed on lines prohibiting this social and health grievance, which menaces civilised life and destroys common decency.

In the matter of dilapidated and insanitary property, of which we have still a considerable quantity in Glasgow, I have not time at present to speak. I would like in some future communication to point out to the Society our weakness in this sanitary aspect. Our Improvement Trust has certainly done splendid work, and Glasgow is brighter and happier now than it was when it began its beneficent operations. But our hands should not be stayed. The dens where depravity and dirt reside, and help death to claim his 50 to 60 per 1,000 per annum, are in our midst at this present time—dark, dismal, and filthy. Those hovels have served their day and generation. But old property dies hard. Like the proverbial cat, it seems to have nine lives; and often when we think it is dead, and has been closed up from humanity, we are surprised to find it again in full activity, with a set of new entrails in its ugly body.

With reference to the working of the "Food and Drugs Act" in Scotland, a most important point is the fact that north of Tweed two individuals are required by law to make a purchase for prosecution, whereas in England one person is sufficient. It is well to protect the trading public from any chance of miscarriage of justice, but a method such as we labour under is highly detrimental to the public interest. The constant adulteration of our milk supplies is another point which loudly for reform. The Somerset House standard of 11.1 per cent. total solids, with 2.5 per cent. of fat, is at the least 1 per cent. below what it ought to be. The standard in Paris is 13 per cent. total solids, 4 per cent. being fat; and after extensive investigations and analyses of hundreds of samples, the Massachusetts State Board of Health adopted the same standard as Paris for total solids. These standards are 1.9 per cent. above ours. Why our public should have to rest content with a standard which permits 10 to 15 per cent. of water to be added with impunity to good milk, cannot understand. It has been proved, doubtless, that individual cows here and there have yielded milk which on analysis shows 9 per cent. of solids not fat and 2.5 per cent. of fat; but to make the legal standard from odd exceptions is direct encouragement to fraud. The average cow gives milk fully 2 per cent. better than the standard, so that in good milk unscrupulous vendors can put 15 per cent. of water, and still escape the meshes of the law. They can even add another 5 per cent. without much fear, as no sheriff cares to take up a case in which the analysis does not show over 5 per cent. of added water over and above that allowed by the Somerset House standard.



XV.—*On a New Composite Electric Balance*. By Sir WILLIAM THOMSON, F.R.S.

[Read before the Society, 4th February, 1888.]

THIS instrument has been designed for the purpose of providing, in one piece of apparatus, the means of measuring (1) the difference of potential between two points of an electric circuit, as, for instance, the difference of potential between the supply-conductors of an electric-light installation; (2) the current flowing in such a circuit; and (3) the rate of working in the circuit. The instrument thus forms a combined voltmeter, ampère-meter, and watt-meter. The general form of the instrument is shown in Fig. 1, Plate III. In this figure, *a* and *b*, are two coils of silk-covered copper wire fixed one above the other, with their planes horizontal, on a slab of slate, *S*. Two coils, *c* and *d*, of similar wire, are made up in the form of anchor rings, and fixed to the ends of a balance beam, *B*, which is suspended by two flat ligaments, *e* and *f*, of fine copper wires, one of which is shown at *e*, in such a position that one of the coils fixed to the ends of the beam is suspended mid-way between the coils, *a* and *b*, with its plane parallel to the planes of these coils, and with its centre in the line joining the centres of them. Other two coils, *g* and *h*, capable of carrying strong currents, are fixed to the sole-plate, *S*, in positions which, relatively to *d*, are similar to those occupied by *a* and *b* relatively to *c*. When the instrument is to be used for the measurement of continuous currents, the coils *g* and *h* are made of several turns of thick copper ribbon, capable of carrying currents up to a maximum strength of five hundred ampères. When it is to be used for the measurement of alternating currents these coils are made of two or three turns of a stranded copper conductor. Each wire of the stranded conductor is covered with silk, so as to insulate it from the others, and, in order as far as possible to annul the effect of induction in causing the current to be different at different distances from the axis of the conductor, the strand is given one turn of twist for each turn round the coil.

The arrangement of the connections in the instrument will be readily understood by reference to Fig. 2, Plate IV. First, suppose the instrument to be used for the measurement of potentials, that is to say, as a voltmeter. It is connected to the circuit through a suitable resistance, R , wound anti-inductively, through which the current passes to the terminal, T , from which the course of the current through the coils to T_1 is indicated by the arrows in the diagram; the switch handle, H , being in this case turned to "Volt." For the measurement of ampères the switch is turned to "Watt," a measured current is passed through the suspended coils of the balance, and the current to be measured is passed through the coils, g and h , by introducing the electrodes, E and E_1 , into the circuit. The current through the suspended coils may sometimes be measured by means of the instrument itself arranged for the measurement of volts. This may be done by first measuring the current which the difference of potential between the supply-conductors of an electrical installation, or between the poles of a battery, causes to flow through the coils of the instrument and its external resistance, and then turning the switch to "Watt," and, at the same time, introducing a resistance into the circuit equal to the resistance of the fixed coils. When the balance is used as a watt-meter the switch is turned to "Watt," and the terminals, T and T_1 , are joined to the two supply-conductors, while the current through the circuit is passed through the coils, g and h . When the rate of working in an alternate-current circuit is measured by such a balance, the anti-inductive resistance, R , must be so great that there is no sensible difference of phase between the currents flowing through the fine wire coils of the instrument and the electromotive force on the supply-conductors to which they are connected.

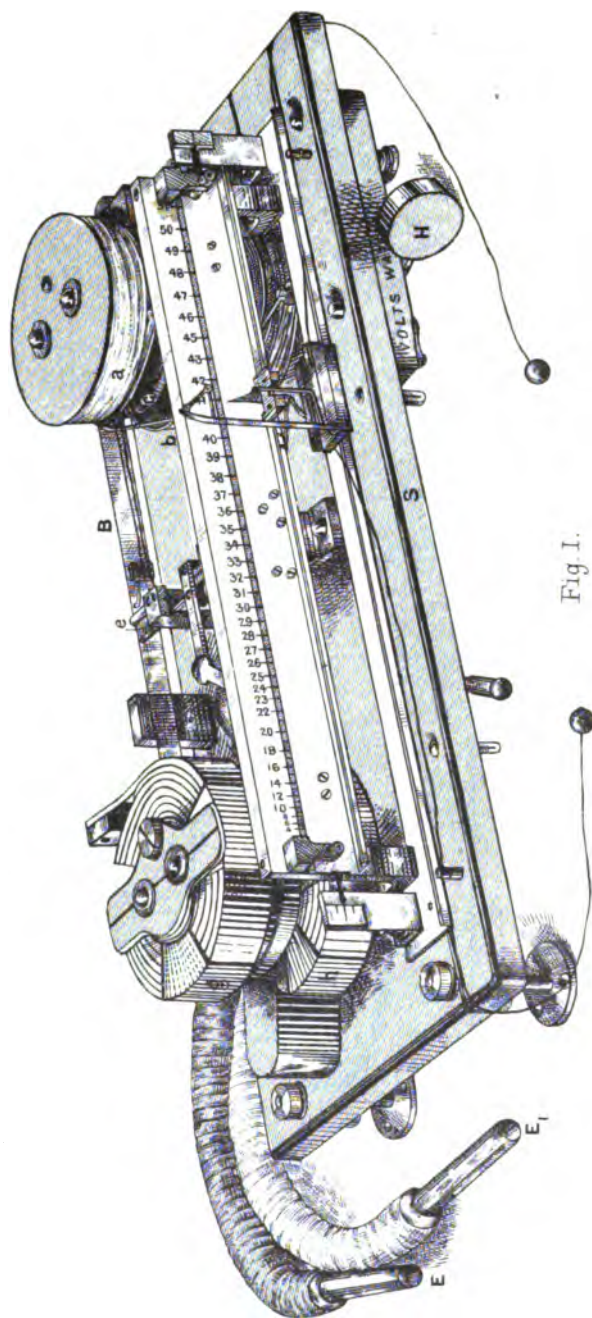
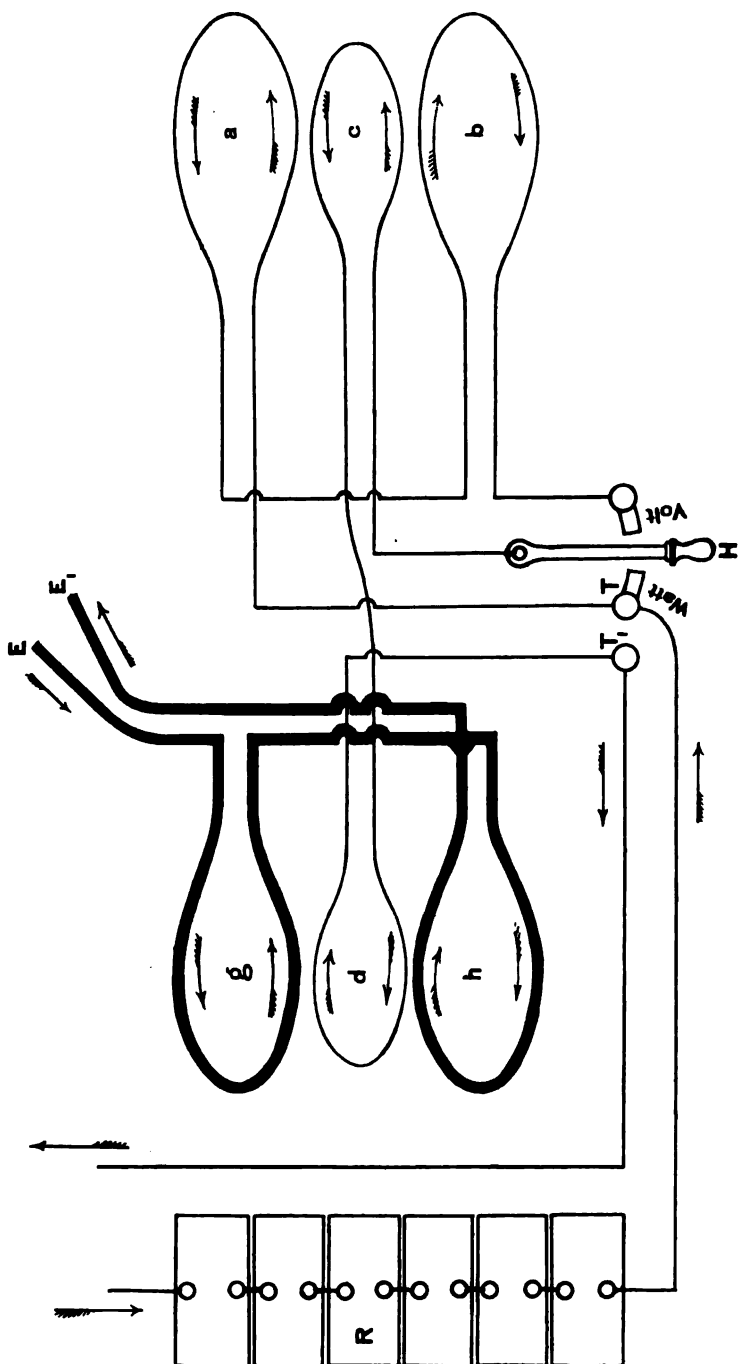


Fig. I.



XVI.—*The Constitution and Course of the Money Market*. By
CHARLES GAIRDNER, President of the Economic Science
Section.

[Read before the Section, 20th February, 1888.]

THE Money Market of the United Kingdom is an institution of great importance and of some complexity. It has gradually grown to enormous proportions, and embraces a fund almost equal in amount to the sum of the National Debt. This fund is held by the banks, is practically at call, and is repayable in gold; yet ninety-five per cent. of its amount is constantly engaged in promoting the industries and material interests of the country and the world, while only five per cent. is actually held in coin. The mode in which this is accomplished is the subject I am to bring before you to-night.

The chief instrument employed by the banks in maintaining the stability of the money market and the convertibility into coin of all their obligations is "the rate of discount,"—a term which I use in a general sense, and intend by it to signify the charge made for the loan of bankers' money. It is an instrument of great power and delicacy in financial affairs, as I shall have occasion to show. Like most questions connected with money, the subject is somewhat abstruse, and, as the difficulties inherent in such questions are often enhanced by the use of terms and phrases not clearly understood, I should like, before entering on my subject, to show the importance of care in this matter.

The basis of money in this country is gold, and "the scarcity of gold" is one of the stock phrases of the day, on which I wish to make a few observations. It is used with the same fluent complacency as if it were "scarcity of cotton," "scarcity of wheat," or of any other article of general consumption, a stock of which is kept for the purpose of maintaining a regulated supply. But while we may agree in holding that the term "scarcity," when so used, means an inadequate stock, having regard to the consumptive demand, present and prospective, the same cannot be said in the case of gold, which is not an article going into consumption at all

in the same sense. What, then, is meant by scarcity of gold? When do abundance end and scarcity begin? At what point do we reach the happy medium when neither abundance nor scarcity can be said to prevail? To these questions no answer is attempted even by those who, because of the alleged scarcity, would have the State to change the standard of value. They would revolutionise the money market, and modify by Act of Parliament the relations between creditors and their debtors, without even attempting to define the extent of the mischief to be corrected, or to gauge the probable effect of the proposed remedy. Vagueness of statement as a basis for important legislation is always to be deprecated, and it would certainly facilitate the consideration of the subject if those who would abolish the gold standard were to show us the draft of a Parliamentary Bill, or the heads of an agreement for a League among the nations, setting forth precisely the reasons for the change and the nature and value of the new money they desire to introduce.

Their opponents, on the other hand, who deny the existence of scarcity, and refuse to attribute the fall in prices to that cause, have equally exposed themselves to critical observation. "How can you say," they ask, "that there is scarcity of gold when money is so abundant that the rate of discount is only one per cent.?" This question is not put merely as an *ad captandum* retort, useful in the exigencies of discussion, but deliberately, and as a conclusive answer to the bimetallists, whose case is based on the assumption of scarcity. Even so careful a writer as Mr. Wells, one of the foremost economists in the United States, adopts it in his argument against the scarcity-of-gold theory, stating that "the years 1875 to 1879 inclusive, taking the English market as the criterion, were characterised generally by an excessive supply of money and currency of all kinds, and the same has been true of the period 1880 to 1886-7, when, if the supply of money from gold was constantly diminishing, contrary results would seem to have been inevitable."*

Now, I am no bimetallist. On the contrary, I disbelieve alike in the theory and the practicability of the doctrine so named; but I should be sorry to encounter its teachers with an argument such as this. They are fairly entitled to the admission that, however difficult it may be to define "scarcity of gold," or to say at what

* *Contemporary Review*, November, 1887, p. 633.

point it begins or ends, a relative scarcity, nevertheless, may, and probably does, now exist; and I venture further to affirm that, assuming that we have been passing from a period of abundance of gold to one of comparative scarcity, then *abundance* of money, that is to say, *low* rates of discount, are precisely what, during the period of transition, ought to have been expected in the money market. I desire also to affirm that the converse of this proposition is true likewise, namely, that on the assumption of our passing from a period of scarcity of gold to one of relative abundance, then the immediate influence on the money market would be in favour of *scarcity* of money, that is to say, *high* rates of discount. This paradox I hope to make clear without any extraordinary demand on your patience.

I will deal first with the hypothesis of increasing abundance of gold, and, in order to bring out the argument clearly, will assume the facts to arise in a highly exaggerated form.

Let me make the supposition that a mountain of pure gold is discovered in our midst, and that the gold-currency countries continue, notwithstanding, to retain that metal as their standard of value and medium of exchange: what, in that case, would happen in the money market? The *vox populi*, which, according to some authorities, is no other than the voice of supreme wisdom, would, I doubt not, exclaim, "Now, at last, shall we have money abundant and cheap"—meaning by cheap, low rates of discount. Yet this expectation would assuredly be disappointed. The extraordinary addition made to the world's stock of gold would greatly diminish its value in relation to, and in exchange for, other commodities—that is to say, the value of other commodities measured in gold would tend to rise, and that enormously. All persons possessed of gold would thereupon desire to exchange it for other commodities, or for property in one form or another, before the great depreciation in the value of gold had fully taken place. This movement would not be confined to the actual possessors of gold. All potential holders of gold—those, for example, who control the deposits in the banks; all mortgagees whose debts are repayable in gold; in a word, all *creditors*—would desire to transform the debts repayable to them in gold into some form of ownership of property.

Nor would the movement stop here. Many would wish to become borrowers of gold money in order further to increase their purchases of property; and just in proportion to the greatness of

the rise—just in proportion, that is to say, to the greatness of the depreciation of gold because of the abnormal addition to the supplies—would be the extravagance of the rates of interest offered by contending borrowers.

It is true that no such thing as the discovery of a mountain of gold has taken place, or is ever likely to do so; but yet gold discoveries were made in 1848 and 1851 of extraordinary importance, for they at once tripled the former supplies from the mines. This sudden, immense, and unprecedented addition to the stock of the metal must, presumably, have operated on the money market in the same direction as would the supplies from the hypothetical mountain, although, no doubt, in greatly diminished degree. It would operate, of course, only as one of many influences which are always at work in that market; and we shall presently inquire how far its action can be traced during what we may call the period of abundant gold supplies.

Before I enter on that, however, let me state the converse case of what may be expected to arise in a period of increasing scarcity of gold. The supposition which I now make is that either the accustomed supplies from the mines have seriously fallen off, or that demands of large amount have come upon the gold bullion market from new quarters—for example, from nations hitherto using silver or inconvertible paper money having resolved to substitute gold for the silver or paper; or that both influences—failure of supplies and new demands—have simultaneously come into operation. That is not an extravagant representation of what has actually occurred during the last fourteen years.*

A scarcity so created, and on a sufficiently important scale, would, according to the theory laid down, tend to raise the value of gold in relation to other commodities. That would mean depression of gold prices, leading to results the opposite of those produced by abnormal abundance of gold, namely, an indisposition to acquire or

* NOTE.—The principal new demands on the gold bullion market since 1871 are estimated to be as follow:—

Germany,—chiefly superseding silver,	... ..	£80,000,000
United States, „ „ inconvertible paper,		100,000,000
Italy, „ „ „ „		16,000,000
		<hr/>
		£196,000,000

Vide Mr. Giffen's evidence before Select Committee of House of Commons, November, 1886.

to retain the ownership of property whose value was tending downwards, and a preference for loans on security, whereby the capital sum might be preserved, resulting, as a necessary consequence, in a reduction in the rates of interest and discount because of the increased disposition to lend.

This, then, being the theory which I have presented to you—namely, that increasing *abundance* of gold will in the first place tend to *scarcity* of money, that is to say, high rates of discount, while increasing *scarcity* of gold will tend to *abundance* of money seeking to be lent, and consequently to low rates of discount,—let us see how far the facts of experience are in harmony with the theory, it being always kept in view that the influence in question, however powerful it may be, is only one of many which are constantly at work in the money market.

The years of abundant gold may be said to date from 1851, when the Australian mines came to the aid of those discovered three years earlier in California, to 1873, when the great German demands for gold were sprung upon the market, then beginning to be more scantily supplied from the mines, and these followed in 1875 and subsequent years by the still more important demands from the United States and Italy. The years of relative scarcity run from 1874 to the present time. In the first period, extending over twenty-three years, we find that the rate of discount at the Bank of England attained the high average of £4 3s. 3d. per cent. In the second period of thirteen years it averaged only £3 3s. 11d., a difference of about one per cent. This may be taken to be a fair test of the comparative rates current in the discount market. In the second period, moreover, as is well known, there has been a great fall in the rate of interest allowed on loans generally, and on all the better class of securities, whether of governments, municipalities, or commercial corporations. So great has been the demand for the debenture and preference stocks of the leading railways, that $3\frac{1}{2}$ per cent. is now more difficult to be got than formerly was 4 or $4\frac{1}{4}$ per cent., and that because of the strong favour manifested during the period for the limited ownership which is enjoyed by the mortgagee or lender. That this tendency to ever lower prices and lower rates of interest will sooner or later become greatly modified, or will entirely pass away when the “catastrophic” disturbances in the gold market have spent their force, is highly probable. Whether it may not already have done so, whether or not apprehensions born in a period of descending prices, and

intensified by so many years of depression, may not have carried these rates to too low a range, are practical questions deserving the most careful consideration. But the particular point to which I desire at present to direct attention, as illustrating the need for carefully thinking out all questions of this abstruse nature, is that the prevalence of low rates of interest is no proof of an abnormal abundance of gold, but that, on the contrary, it may be excellent evidence in support of the opinion that gold is becoming relatively more scarce.

So far I have been discussing the influence exercised on the course of the money market by great movements of an exceptional kind, proceeding from changes in the relative value of gold and other forms of property, and whose action on the rate of discount arises from the effect they have on prices. I now go on to inquire into the working of the money market itself, and into the means by which the stability of the system, and the convertibility into coin of the debts of bankers and their constituents are maintained.

It will be convenient to proceed by considering—*First*, the conditions of the money market, apart from any particular system of banking; *Second*, the system of banking in the United Kingdom, apart from the Bank Acts of 1844 and '45; *Third*, the influence exercised by the Bank Acts.

I. The conditions of the money market apart from any particular system of banking.

Banks are the custodians of the spare funds of the people, and are entrusted with them on condition that these funds shall be repaid in coin on demand. Notwithstanding this condition, it has been shown by experience that coin being only useful in commerce as a means of facilitating the exchange of other commodities, a large portion of these funds may be used by the banks by way of loan and investment, provided there be retained in coin such an amount as is sufficient to meet the public demand. The funds held by bankers thus come to be represented partly by *coin*, partly by other forms of property, these latter being, *First*, the cotton, corn, produce, manufactured goods, &c., against which bills are drawn and taken to the banks for discount; and, *Second*, Government or other securities, which are of the nature of mortgages over the property of the nation, corporation, or individual whose obligations they are.

Now, from the condition on which the funds are held by the banks, it is clear that there is a point below which they cannot

safely permit their specie reserves to go. They must take care that such an amount of specie is retained as will ensure the convertibility into coin of all claims upon them; because any doubt on this point will be apt to create a demand for specie, proceeding from distrust. Banking, then, is based upon confidence that the banks shall—*First*, maintain a specie reserve sufficient to meet all demands; and, *Second*, exercise a prudent discretion in the amount and character of their loans and investments in view of the fact that the funds may at any time be withdrawn or transferred from them.

That the funds held by bankers, and the demand for them in loan, are fluctuating, arises from the fact that they have their origin from transactions outside the banks. These transactions have relation to the cultivation, manufacture, sale, and distribution of commodities; the payment of salaries and wages; the payment of the principal and interest of debt, whether of governments, corporations, or individuals; and to all the varied dealings of men. Yet, however extensive and intricate these transactions may be, they all draw towards a focus through the banks, which stand towards them in the relation of paymasters and collectors of debts. If the transactions occasion no disturbance in the *due proportion* between the two great groups of banking assets—coin and other forms of property,—the charge made by bankers for their loans may likewise remain undisturbed. If they tend to increase the coin of any one country beyond the needful amount, the banks of that country will be warranted in increasing their advances and reducing their charge for loans, and they will probably do so, if thereby they can, on the whole, make greater profit. If the tendency be to diminish the coin reserve, the banks must watch any near approach to the *safety-point*, and, by raising their charge and reducing the amount of their advances, maintain at all hazards such a stock of coin as will protect their credit for “convertibility.”

Thus, then, we see something of the general principle which must regulate the conduct of bankers, and which directly influences the rate of discount. It is founded on the relation from time to time existing between the two groups into which banking assets are divided, “specie” and “other forms of property.” This relation or proportion is constantly changing, and while, as already stated, there is a *safety-point* below which the specie reserve cannot without danger be permitted to go, it is to be observed that that *safety-point* cannot be expressed in any uniform arith-

metical proportion. It is not a mechanical thing which may be allowed to work automatically, but, on the contrary, must be regulated by experienced men. Experience has shown that certain developments, such as war, famine, reckless trading, excessive expenditure, the undue conversion of moveable into fixed capital, great movements, such as we have been considering, affecting the supply of and demand for gold, will almost certainly operate in particular directions, and whenever they are foreseen they should be reckoned with, for it must be remembered that raising the rate of discount or calling in advances will not at once replenish the specie reserve. These proceedings require time to tell, and do tell only through the gradually lowered prices of securities and commodities, the gradually diminished profits and consequent restriction of trade, and by the inducements thus offered to capitalists to bring their money home. England is the creditor of almost every other nation, and is able in a few months or weeks to replenish her coin reserves from other countries; but the evident need for *time* to effect this makes it essential that a reserve be at all times maintained sufficient to meet every demand during that necessary time. Any failure in this may seriously shake the fabric of commercial credit.

It has also to be observed that fluctuations in the amount of the reserve may often take place without necessitating any action whatever on the part of the banks. Such fluctuations are occasioned, for example, by the natural and well-understood increase of the coin in actual circulation at the quarterly terms, when wages, salaries, dividends, rents, are mostly paid. The coin so passing from the coffers of the banks into the hands of the public, returns to the banks after a brief period of service, and in ordinary circumstances its return may be absolutely relied on. Even withdrawals to meet a foreign demand arise from causes so different in their nature that they must be differently judged, and thus, as already said, it is evident that the variations in the specie reserves are not to be checked mechanically. In dealing with them action must be guided by judgment and experience.

In connection with this it will be useful to note that the causes of the variations in the specie reserves may all be classed under three heads:—

1st.—The natural increase or diminution just referred to of the coin in active circulation at home.

2nd.—Receipts from, or payments to, foreign countries.

3rd.—Private hoarding. This class is now comparatively little known in this country, and so is apt to be overlooked ; but it must be remembered that its absence is solely owing to the high credit of the banks, and that it will reappear in the event of that credit being seriously called in question.

II. *The system of Banking in the United Kingdom apart from the Banking Acts.*

Hitherto I have spoken of the banks as if they were in all respects alike, and while considering the general conditions of the money market, I have thereby been enabled to disembarass the subject of some considerations of a practical kind affecting the banks of the United Kingdom, which must now be taken into account.

The first of these is the fact that the banks throughout the country, taken individually, do not within themselves maintain their own specie reserves. It has already been explained that the transactions of the people draw towards a focus through the banks, from the banks acting as the paymasters and collectors of debts for the people. These debts, from the bankers' point of view, come to be, in the main, matters of account, the balance only that may be due to or by individual banks falling to be actually paid. If each bank kept its own specie reserve, payment of these balances would no doubt be effected by a transfer of coin from the vaults of one bank to those of another, and a continual process of conveying coin to and fro in settlement of daily balances would be necessary. To avoid this needless trouble and risk, the practice has grown up among the country banks of settling their balances at one common centre, and that centre is London, where is the bullion market of the kingdom. All payments, then, by one country bank to another are made by draft on a correspondent in London, and, for this reason, London is the place where the reserves of country banks require chiefly to be maintained.

But, secondly, the London banks do not, any more than the country banks, keep their own specie reserves. Were they to do so, the same needless labour and risk of conveying coin to and fro among themselves would arise ; so, to avoid this, the practice has grown up among them of maintaining their reserves in one place, and that place is the Bank of England, which is the Bankers' Bank. All balances due from day to day by one London banker to another are settled by draft on the Bank of England, and here, therefore, we seem to have reached the very point of the focus.

Yet it is not so. These reserves of bankers held by the Bank of England are still further economised, for the bank uses them by way of loan and investment to such extent as the directors of the bank deem right; and thus we find that practically, and apparently by common consent, there is delegated to the directors of the Bank of England the grave responsibility of judging what amount of specie reserves shall, from day to day, be maintained for the whole nation.

In connection with this responsibility, it must be observed that the Bank of England has no knowledge either of the extent or character of the liabilities of those banks whose reserves it holds, nor does the bank know the purposes for which advances by these banks are being made, nor how far they may lead to the efflux of specie from the country. What the bank does know is that all the influences on the reserves may be classed under the heads of Inland circulation, Foreign exchanges, and Private hoarding, and they must so study the economic condition of the country, and the progress of events affecting the material interests of the people, as not to fail in maintaining the convertibility into gold of all their obligations.

This is the system in actual operation, considered apart from the special legislation of the Bank Acts. It is certainly a highly centralised system, and enables the banks to economise the use of gold in a very remarkable degree. It is clear from it that an extraordinary importance must always attach to the increase or diminution of the bullion reserve at the Bank of England, for it is chiefly by watching these fluctuations that the question can be solved how far the specie reserves of the United Kingdom are being adequately maintained.

III. *The influence exercised by the Bank Acts of 1844 and 1845.*

These Acts proceed on the preamble that "it is expedient to regulate the issue of bills or notes payable on demand," and the mode of regulation adopted is by prohibiting the institution of any new bank of issue and imposing on those in existence certain stringent conditions. It is not my intention on this occasion to enter on the general question of bank notes, a question which would require at least one evening to itself, and I, therefore, only ask your attention to the manner in which the regulations of the Bank Act exercise an influence on the reserves of coin.

The general principle of the Acts of both years is that gold

must be held by the banks of issue, individually, for whatever sum their actual issues exceed their authorised issues. Under the English Act this general principle is qualified by the fact that the country banks of issue in England are prohibited from exceeding, under any circumstances, the amount of their authorised issues, a prohibition which has the effect of compelling them to use the notes of the Bank of England to the extent whereby the demand upon them for notes exceeds their authorised issues. Any expansion of notes in England, then, beyond the amount authorised in the Act, is necessarily an expansion of the note circulation of the Bank of England. In Scotland and in Ireland, on the other hand, the banks may increase their circulation to any extent in accordance with the public demand, provided that they have gold at their principal place of issue to an amount not less than the amount of such increase, ascertained as I shall presently explain.

This being the general principle of the Bank Acts, there has to be noted a very important difference in its application in England as compared with Scotland and Ireland. At the Bank of England, where alone in England any expansion of note issues can take place, the official arrangements of the bank are divided into two distinct departments—a note-issuing department and a banking department. From the note department no notes can legally be issued, even for an hour, in excess of the authorised amount, *plus* the coin in that department. It follows from this that a sudden demand for notes made on the banking department sufficient to exhaust their reserve will create a dead-lock.

In Scotland and in Ireland, as already indicated, no such dead-lock need take place, because any demand for notes, to whatever extent it may go, may be legally complied with provided that *on the average of four weeks*, ascertained at the close of business on each succeeding Saturday, the issuing banks respectively hold, at their principal place of issue, an amount of gold corresponding with the excess of issue beyond the authorised amount. Contravention of this provision would involve a certain pecuniary penalty on the offending bank, but contravention is improbable and unnecessary because of the time allowed for strengthening the stock of gold through the principle of average over four successive weeks.

From the point of view of the central specie reserves, then, we have here a cause of disturbance acting upon them, additional to those I have previously described, arising out of the fluctuations

in the amount of notes in active circulation. In ordinary times the causes of such fluctuations are well understood, and can be provided for by anticipation. In times of crisis it is very different. Then the note circulation is almost certain to expand, and for this reason, that when distrust prevails the banks throughout England prudently strengthen themselves by increasing their stocks of legal-tender money in the shape of Bank of England notes. This demand, if sudden, as it is apt to be, cannot but be inconvenient to the bank at such a time, because the replenishing of the bank's reserves by raising the rate of discount takes time to tell, and time is not allowed under the Act of 1844 as under those of 1845. In this fact rests the chief explanation of the suspension of the Bank Act in October, 1847, November, 1857, and May, 1866. Vigorous measures were taken by the bank on each of these occasions, and on the last the rate of discount was, within seven days, raised from 6 to 10 per cent.; but before there was time for this step to have its effect, the Government of the day found it necessary, on the application of the directors of the bank, to suspend the provisions of the Act.

Perhaps it may be said that now, after forty-three years' experience of the Act, it is better understood, and the old difficulties will not again be allowed to recur. This view may seem justified by the fact that it is twenty-one years since the Act was last suspended. It may also be said that within that time a new power in the interest of stability has been largely developed in the great extension of that class of securities which is international in character, and which can therefore be made instrumental in attracting gold from abroad. Much importance, undoubtedly, attaches to this last fact, and it is another proof that the difficulty of replenishing the reserves of gold is not, in this country, one of means, but simply one of time. It is the suddenness with which an increased demand for notes may deplete the reserves that has to be warded against; and as the reserve in the banking department, which, on the average of five years ending 31st December, 1865, was £8,330,000, has only been raised, on the average of the five years ending 31st December, 1887, to £13,305,000, an increase of only £4,975,000, it may reasonably be doubted whether, having regard to the great increase that has taken place in the banking liabilities of the country, such an enlargement of the reserve can be considered an adequate protection.

As regards the fact that we have had immunity from suspension

during twenty-one years, I would remind you that in my opening remarks I showed that during the last fifteen years we have not had financial conditions such as ordinarily precede or lead to a great panic. These conditions are usually associated with rising prices, accompanied by much speculation and undue inflation. Since 1873 we have had no such experience, but, on the contrary, a time—dreary and depressing to all holders of property—of falling prices, unrelieved by almost a single glimpse of an upward tendency. Such financial catastrophes as have occurred have been mainly confined to particular commercial coteries, those, for instance, in London in 1875, and in Glasgow in 1878; but these, though disastrous to many individuals, were not enough to shake the credit of the country generally as it was shaken in 1866. Should the cycle of falling prices prove to be for the present closed, and a more buoyant period be in store for us, the kind of financial difficulties hitherto associated with rising prices may not improbably be found to repeat themselves.

Before drawing to a conclusion, it may be interesting if I place before you a more exact idea than I have yet presented of the aggregate sums controlled by the money market. This can only be done approximately, because the private banks, and a small number of the joint-stock banks, do not publish balance sheets; but, according to the carefully constructed tables of the *Economist** newspaper, the facts are believed to be nearly as follow:—

Estimated total of deposits and current accounts held by banks in United Kingdom, exclusive of Bank of			
England,			£550,000,000
Bank of England,			33,000,000
			£583,000,000
Active circulation of notes, say—			
Bank of England,		£25,000,000	
Country Banks—			
England—Private, £1,200,000			
Joint Stock, 1,300,000			
		£2,500,000	
Scotland—Joint Stock,	5,500,000		
Ireland—Joint Stock,	5,000,000	13,000,000	38,000,000
Total of cash liabilities,			£621,000,000
The above is exclusive of the paid-up capital of the banks,			

* 22nd October, 1887.

which, as regards the joint-stock banks, amounts to £70,000,000, and is exclusive also of the deposits held in this country by the Colonial and Indian Banks, which must amount to a very large aggregate, but which, not being, as a rule, repayable on demand, belong to a different category from those I have been considering.

On the other hand, the stocks of coin and bullion may be estimated thus:—

Bank of England,	£20,000,000	
Banks in Scotland.	4,000,000	
Banks in Ireland.	3,000,000	
		£27,000,000

If we set down for the Joint Stock and Private Banks in England which make no return,	8,000,000
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The estimated aggregate stock of coin and bullion is £35,000,000

Applying these figures to the system of banking in the United Kingdom, as I have explained it, we find that—

Against liabilities practically at call and repayable
in coin, amounting to £621,000,000
there are held—

Coin and bullion,	£35,000,000
And documents representing commo- dities and securities.	586,000,000
	£621,000,000

But of the £35,000,000 of coin and bullion there was locked up in the note department of the Bank of England, at the date of the returns, £8,000,000, because of the excess of active circulation beyond the authorised circulation of the bank. Deducting this £8,000,000 from both sides, the figures stand—

Liabilities,	£613,000,000
Coin and bullion,	27,000,000

equal to about $4\frac{1}{2}$ per cent. of the liabilities.

This sum of £27,000,000 includes the reserves held by all the banks in the United Kingdom that are available to meet demands for Inland coin circulation, Foreign exchanges, and Private hoarding, and also the provision against any increase in the active note circulation of the Bank of England. That it could in a few months or weeks be increased to any required extent is beyond doubt. But this operation requires time, and the practical question for consideration is whether or not the sum of £27,000,000, which may be taken as a fair average of the national reserves in ordinary times, is an adequate provision to meet all demands in the circumstances explained.

It would be an easy matter to criticise the constitution of the monetary system which I have thus imperfectly described, and to point out defects, not to mention anomalies, in some of its details ; but it must be remembered that any new system, even if logically perfect as regards its structure, would be but an arrangement of dry bones. The existing system is much more than that. It is in vigorous operation ; it possesses the traditional experience of many generations ; and, having a record of important service rendered to the nation, it now enjoys, notwithstanding occasional instances of grave mismanagement, the full confidence of the people. This reputation, or "credit," has an importance which cannot be expressed in figures, but which, nevertheless, is of the greatest practical value to the banks and the public. In attempting to improve the system past experience will be the safest guide, and this has led me to indicate two points as having the foremost claims to attention :—

First, the want of flexibility in the relations between the note and the banking departments of the Bank of England has in past times forced the suspension of the Bank Act. A partial remedy, at least, is to be found for this in the Act of 1845, where the principle of *average over several weeks*, in the prescribed amount of coin to be held, takes the place of the hard-and-fast rule of the earlier Act.

Second, the increase made in the central coin reserves bears no adequate proportion to the increase in the wealth of the nation or the responsibilities of bankers. A remedy for this, also, is in our own hands, and the extension to England of one-pound notes would liberate the necessary coin, now needlessly circulating as pocket and till money, and send it to swell the reserves at the centre. Happily the feeling in England against the grievance of light gold is becoming stronger than the old antipathy to one-pound notes, and so an opportunity for this salutary strengthening of the reserves may ere long present itself.

If suitable occasion should thus arise for considering the amendment of the Bank Act, and suggestions such as I have ventured to make be carried into practice, I would anticipate, thereafter, a lessened tendency to panic in times of stringency, and, as a rule, greater steadiness in the rates of discount, because of the broader basis on which the national finances would then rest, and of the more flexible relations that would exist between the two departments of the great central bank. There would be no new principle

introduced which is not already recognised in our banking legislation ; and although such modifications would not satisfy our root-and-branch reformers, they could create no apprehensions in the minds of the most uncompromising upholders of the Acts as they stand. If, in course of time, new developments in commerce should appear to demand greater reforms, I would, for my part, still counsel adaptation of the old system to the new circumstances, rather than the seeking after theoretical perfection. No two nations adopt the same principle in reference to their reserves of coin, and it is highly improbable that the system, or the proportion of reserves to responsibilities, that would be appropriate to one country would be so to another. The money market of a country is of indigenous growth, and ought to be considered with relation to the circumstances which have produced it, and the services it has to render. I hope I may have been able, to-night, to interest you in the constitution of our own, and to throw some light on the various influences, from without and from within, by which it is liable to be affected.

XVII.—*On the Measurement of Electric Currents by the Electrolytic Deposition of Copper.* By ANDREW W. MEIKLE,
"Thomson" Experimental Scholar, University of Glasgow.

[Read before the Society, 22nd February, 1888.]

THE subject which I wish to bring before you very briefly is the measurement of electric currents by the electrolytic deposition of copper. In doing so, I do not propose to deal with the question of electrolytic current meters, but shall confine myself entirely to the use of the electrolysis of copper sulphate as a means of standardising electrical instruments. An investigation was made about two years ago in the Physical Laboratory of Glasgow University into the question of the reliableness of copper electrolysis as compared with silver, and the results of these experiments were communicated by Mr. Thomas Gray to the *Philosophical Magazine* for November, 1886. The conclusion drawn from the investigation was that, while silver in the hands of a trained experimenter leaves nothing to be desired in point of accuracy, still it is open to the objection of difficulty in manipulation, while for large currents, owing to the very large area of plates required, it would be much too costly and troublesome to use. Copper, on the other hand, has the advantage of simplicity in management, and where attention is given to a few necessary precautions great accuracy can be obtained. Since the time of that investigation the electrolysis of copper sulphate has been largely employed for standardising Sir William Thomson's standard electric balances, and has always given the most satisfactory results.

Before going into the subject any further, I would like to show you some of the apparatus. It is very simple, as you see, and is such that anyone could make it for himself in a very short time. It consists simply of a rectangular frame, round the edge of which, at intervals of about five inches, are fixed a number of spring contact clips, all of which are well insulated from each other by india-rubber tubing. All the clips on one side of the stand are

single, while those on the other side are double. (See Fig. 1, Plate V.) These double clips are for holding the loss-plates, or those by which the current passes into the cell, and from which the copper is deposited upon the plate held between them by the single clip. The electrolytic cell is simply a round glass jar, nearly filled with sulphate of copper, into which three vertical plates held by the clips are placed. This mode of placing several sets of clips on a frame is very convenient, as the plates are easily adjusted in position, and it suits very well for currents up to about fifteen amperes by joining the cells in series or parallel, as may be necessary. It also has the advantage that, when using the cells in parallel for the measurement of currents up to ten or fifteen amperes, the plates, owing to their comparative lightness, can be weighed on a chemical balance, the additional number of weighings being more than compensated for by the additional accuracy obtained.

For small currents it is advisable to run two or even three cells in series, as with small deposits a check is thus obtained on the weighings, or on any defect in an individual cell. It is also best to run small currents a sufficiently long time to make any error in weighing a very small percentage of the total deposit.

For currents from 20 to 200 amperes, owing to the large amount of copper deposited, such delicate weighing is not necessary, and a cell of different shape, with much larger plates, is used. This cell and the arrangements for large currents are very fully described in the paper by Mr. Gray previously referred to.

The gain-plates are made from ordinary high conductivity copper. They are cut in the form shown in Fig. 2, as this shape of plate, owing to the flexible tongue, is very easy to adjust in its position, and when in use only the narrow strip necessary to hold the plate between the contact clip is left exposed to any possible risk of oxidation by the atmosphere. The edges of the plate are all carefully smoothed, and its surface is burnished with fine glass paper, which must be thoroughly dry and clean, until perfectly bright. It is then rubbed with a piece of clean cloth, and finally wiped with a silk handkerchief to remove shreds, after which the plates are ready for weighing.

We have found it very convenient to burnish the plates on a wooden roller, one half of which is covered with a sheet of fine glass paper, and the other with a piece of cloth or velvet. This cylinder is made to revolve rapidly in a turning lathe, and the plates are held gently against it by means of a pad, any grains of sand

being readily removed by the velvet pad at the one end of the roller. Care should always be taken in cleaning the plates not to touch with the fingers any portion intended to be immersed in the solution, as by so doing the surface is spoiled for a deposit. The loss-plates are also made from high conductivity copper, but from a thicker sheet, so that they may last for some time. No great trouble is taken with them, except to see that they are never put into the solution when oxidised. The solution is made by dissolving commercial copper sulphate in clean water, as it comes from the Glasgow water pipes, until a density of from 1.15 to 1.18 is obtained. One per cent. of free sulphuric acid is then added, as it has been found from experience that, unless the solution is decidedly acid, the plates are oxidised in the solution and very irregular results are obtained, which are quite valueless for accurate standardising. On this account the solution should not be used too often, as the acid is after a time exhausted by action with the plates.

The Table of Curves, No. I., gives five curves which were obtained from experiments with ten cells in series and different areas of plate in each. Curve 1 is the mean of about twelve or thirteen experiments made with free acid in the solution. Curves 2 and 3 are taken from two single experiments, also with about one per cent. of free acid. It will be observed that these three curves are exactly similar in form. Curve 4 is taken from an experiment made with solution which had been used too often, and you can see how irregular it is as compared with the others. The fifth and very irregular curve is taken from an experiment made with solution from which all the acid had been withdrawn by the putting in of some oxide of copper. The gain-plates were found to be very much oxidised when taken out of the solution, and were quite brown in colour.

From the remarks which I have made, it will be seen that as the plates lose weight in the solution some correction will be necessary for different current densities at the cathode or gain-plate. This is a subject which has been very fully investigated in the Physical Laboratory. We have also gone into the effect of temperature on the correction to be made, and the results of the experiments are shown in these curves (Table No. II.), which I shall speak of presently.

The experiments were made with ten cells in series, all carefully insulated from each other, and each cell having a different area of

gain-plate, the extreme range being from about 20 to 500 sq. cms. per ampère. The solution used in all cases was 1·17, with one per cent. of free sulphuric acid added. From former experiments described in Mr. Gray's paper, no difference could be observed in the amount or appearance of deposits from solutions containing percentages of acid varying from $\frac{1}{2}$ per cent. to 5 per cent. at a temperature of about 12°C. Owing to the very rapid consumption of the free acid in the solution at the higher temperatures, however, fresh solution was used every time.

The curves in Table No. II. show the results obtained for different areas of cathode or gain-plate. Each curve is for a different temperature between 2°C. and 35°C. The curves all converge rapidly towards the point of crossing, which shows that the same deposit would be had at all temperatures with a small enough area of plate, but, as the deposit for areas under 20 sq. cms. per ampère is never very adherent, no plate was used under that point. The curves were produced to cross the line, and the point of crossing was taken as 10,000, the other points being reduced to correspond, so as to render percentage corrections easy for different sizes of plates. The ordinates are therefore numbers proportional to the weight of copper deposited in grammes, while the abscissæ are areas in sq. cms. per ampère. The curve for 2°C., which is near the freezing point of copper sulphate, is the mean of three experiments which were in very close agreement. It is rather curious that for a range of current density almost up to 150 sq. cms. per ampère there is no effect made by variation in area of plate, but the same tendency is shown in the curves for 12°, 23°, and 28°, although to a much smaller extent. The curve for 12°C. is the mean of a large number of experiments which were in very good agreement amongst themselves. The effect of temperature from 10°C. to 15°C., which is about the ordinary range of temperature in the Physical Laboratory of Glasgow University, is very small, and may be neglected. Indeed, with a gain-plate of 50 sq. cms. per ampère, the total variation in the corrected equivalents for 12°C. and 28°C. is only about $\frac{1}{16}$ per cent. The curves for 23°C. and 28°C. are two single experiments, while the curve for 35°C. is the mean of two experiments which were in good agreement with each other. The effect of temperature rapidly increases as it approaches 30°C., until at 35°C. a degree or two degrees of difference in the temperature of individual cells produced a marked irregularity in the curves. In hot climates, therefore,

the effect of temperature would require to be very carefully allowed for.

Standardising Arrangements.—The arrangements for standardising are very simple, and consist in joining in series a constant battery, the instrument to be standardised, the electrolytic cells, and a variable resistance. Care should always be taken to join the instrument directly on to the electrolytic cells, and to have that portion of the circuit well insulated, so as to be sure that the instrument is recording the whole amount of current which is passing through the cells. The simplest form of arrangement is shown in Fig. 3, Plate V., and is suitable for currents up to about ten amperes. For currents up to one ampere a high resistance rheostat of platinoid wire is used, and for currents above that one of stranded copper wire. For large currents beyond the carrying power of any rheostat, a conductivity bridge is put into the circuit, and is joined in parallel to the copper wire rheostat, as shown in Fig. 4, Plate V.

The apparatus having been arranged in the way mentioned, trial plates of the same area as the gain-plate to be used are put into the electrolytic cell, and the current is adjusted to the required reading on the instrument. The circuit is then broken, the cleaned and weighed gain-plates are put in and the current is again made—the exact second being noted on an accurate time-keeper. The instrument, which should be found very nearly to record the desired reading, is at once adjusted by turning the rheostat, and by that means is kept steady during the experiment. Any error arising from the current not being at the proper strength on starting is very small. As a rule, the current, when previously adjusted as described, is, practically speaking, exactly right when made for the standardising, but if it chance to be even so much as 5 per cent. wrong, an amount which, with the precautions taken, is entirely out of the question, it could easily be set right in ten seconds with apparatus such as has been described. This would give an average error of about $2\frac{1}{2}$ per cent. for ten seconds, or about $\frac{1}{140}$ per cent. on an experiment lasting for one hour. The current should be run until the amount of the deposit will be such that any possible error in weighing or in starting and stopping the current is practically eliminated. In breaking the current the exact second is again noted, and the plates are quickly removed from the clips and placed in a glass vessel containing pure water, with a few drops of sulphuric acid added to prevent oxidation. From this they are

which is a thin layer of pure water quickly dried on clean drying paper and then kept before use to remove any trace of moisture which may remain after which they are ready for weighing.

In addition I may mention that there is at present in the Physics Laboratory of Glasgow University a chain of standard resistances capable of measuring from one centi-ohm to 100 ohms whose values have been separately determined by the method I have just described which I have described. These resistances are practically speaking in absolute agreement with the values of the standard resistances preserved between any two of the set and have a resistance when compared together, which is not more than one part in a million the great value of the method is demonstrated, and that it is equally reliable in the case of a standard resistance.

Fig 1

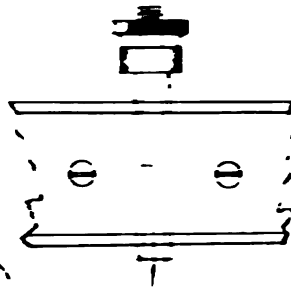


Fig. 2.

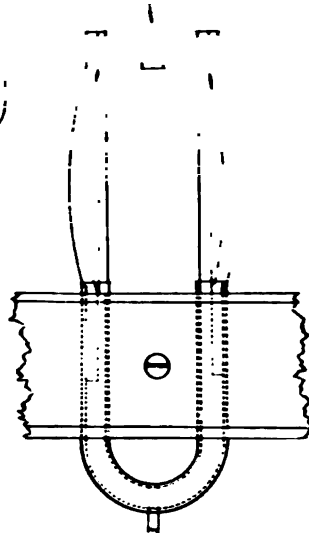
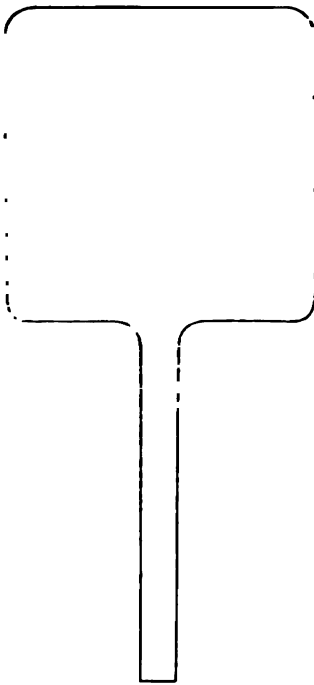


Fig. 3.

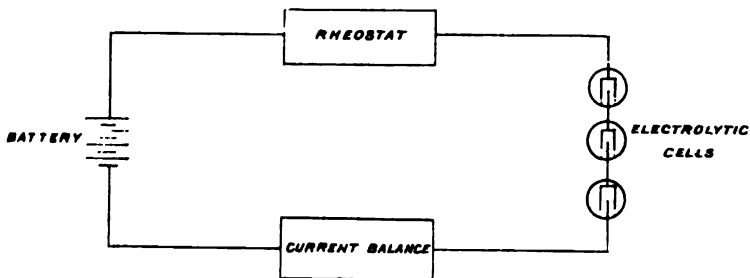
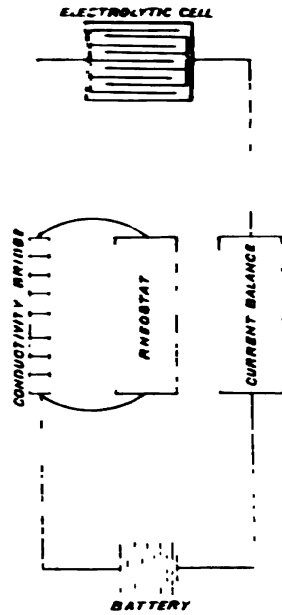
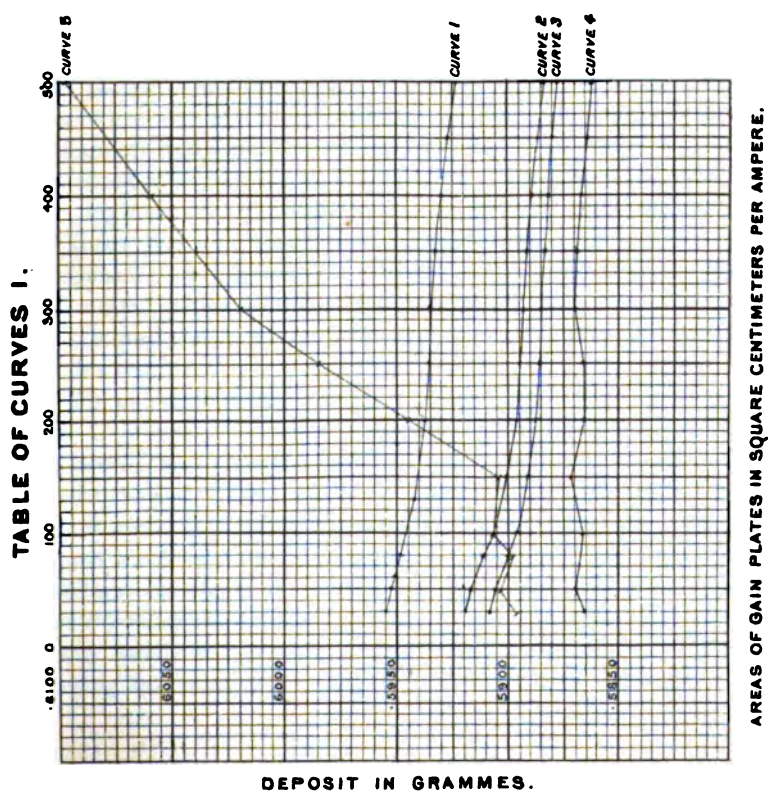
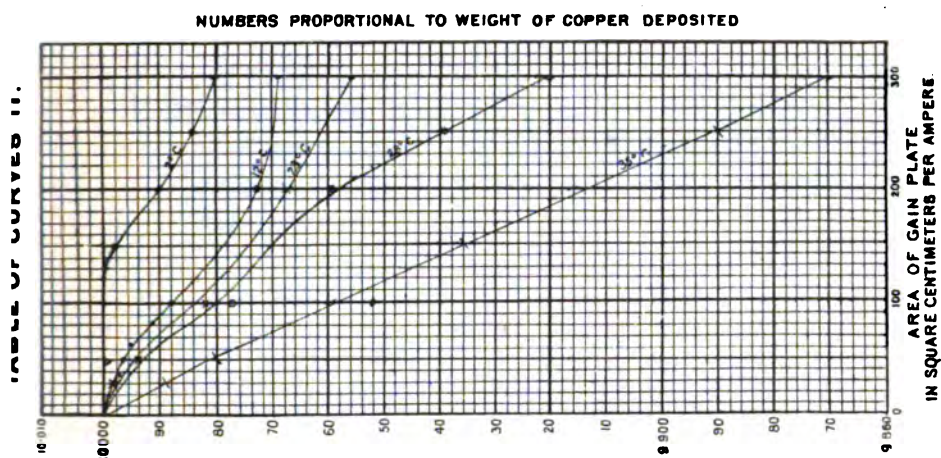


Fig. 4.





XVIII.—*On Noxious Vapours and Town Smoke, with Suggestions on House Warming*. By ALFRED E. FLETCHER, F.C.S., F.I.S., H.M. Chief Inspector under the Alkali, &c., Works Regulation Act.

[Read before the Society, 25th January, 1888.]

YIELDING in an unwary moment to the seductive invitation of your excellent President, Dr. Russell, I consented to read a paper before you this evening on Noxious Vapours, including Town Smoke, and to touch on a subject that leads naturally from this—namely, House Warming. I will do my best now to fulfil the promise, asking your forbearance beforehand should my lecture partake of the dullness inherent in the subject of which I treat.

I will not take up your time by dwelling on the necessity of our having a sufficient quantity of air to breathe, remarking only that the air should be unmixed with any foreign gas, whether that gas be one that is actively hurtful to our bodies or whether it is to them inert and serves only to dilute the air we inhale. The air, composed of oxygen and nitrogen with a little carbonic acid and a varying quantity of watery vapour, is not a definite compound of these, but a mixture only, and one that can be modified by diminishing or increasing one or other of its ingredients. The same relative proportions of its constituents is, however, steadily maintained, thanks to the many agencies in nature ever working to this end.

The animal breathes the air, and oxygen is absorbed into the blood. There it combines with effete matter, composed chiefly of carbon and nitrogen, forming with them carbonic acid and watery vapour. These are exhaled and mix with the atmosphere, which would soon be thus vitiated but for the corrective action of plants which take up the carbonic acid and under the influence of sun-light decompose it, assimilating the carbon into its structure and returning the oxygen to the atmosphere. And lest this action should locally be impeded and air of irregular composition be found lurking in places, the atmosphere moves in mass from place to

place, and the winds of heaven search out every nook of valley and forest, to the end that by incessant mixture the air should retain its normal condition, its parts being ever mixed in just that proportion which is best fitted for the respiration of man and beast. If, then, nature is so careful to maintain the pristine condition of the air we breathe, let us imitate her care and use every practicable means to avoid its contamination.

Man in all the methods of his activity seems to be ever at war with nature; he subverts her arrangements and attacks her at every step. She in turn resists him and impedes his progress. The settler in a new country commences his operations by cutting down and destroying the branching forest which adorns the hill-side; he thrusts in his ploughshare and breaks up the tangled under-growth. It is true that in time a lovelier prospect may present itself than the primeval one which has been disturbed, nevertheless man's first act seems to be to disturb and to injure. As in the earth so is it in the air, that this part goes on and is ever more extended as man's activity increases.

Man's very act of breathing contaminates the air, and the more he works the more he breathes. He lights a fire to warm himself and cook his food—the injury is accelerated. Population increases, the common war against nature goes on, and no heed is given until she retaliates. The return blow is not, however, always aimed at the original offender; often the innocent suffer for the crimes of others. One man is a chemical manufacturer; he sends into the atmosphere gases for which he has no present use; the injured air moves on, and passing over the ground of a neighbouring farmer wreaks vengeance there by killing his crops.

If, in general, a man's ill deeds affected himself, and the only results of his actions fell wholly on his own head, there would be less complaining and the evil itself would be much curtailed. It is not so, however, and the case before us—that of contamination of the atmosphere—is no exception to the general rule.

What is a noxious vapour? Let us not stay until we are satisfied with an answer to that abstract question; rather let us say some vapours are noxious.

Can all noxious vapours be prevented? I think not wholly. They may be lessened, but not wholly suppressed. The preliminary remarks in this paper have been intended to lead up to this negative reply. Dirt seems to be one of the unavoidable accompaniments of man's work—of his attack on nature in the

pursuit of objects necessary to his existence. But just as a brighter prospect grows up under the cultivator's hand than was seen in the wildness of nature, so the gain of the manufacturer is an ample reward for the dirt and turmoil of his processes.

The material of the white paper from which I read was in colour as brown as is the floor on which I stand, until it was bleached by chlorine, an irritant noxious gas. The dye which colours the garments we wear is the result of manufacturing processes from which noxious vapours abundantly may proceed. The brighter tints of women's dress can boast no different parentage. The metals which we use on every hand are the outcome of smelting processes, the sulphurous fumes from which are noxious in the highest sense. It would, indeed, be difficult to name any article we use whose substance, texture, or colour has not been produced by some manufacturing process, during the conduct of which some noxious gas has been evolved.

You groan! the burden grows too heavy. Is this the price we pay for our vaunted civilisation? Can we not shirk it? No, verily, but we may compromise with the creditor. Let the skill used to elaborate the much-valued result be employed to avoid, as much as is possible, the injury committed. If due diligence is bestowed in this direction there will be but little ground left for complaint. Much, indeed, may be done to diminish, and yet again diminish, the amount of noxious vapour emitted, until the residue is small and comparatively harmless, but utterly suppress them we cannot.

Forgive if I have been so long in reaching this point; its importance is my excuse. If not positively acknowledged, we aim at a mark to which we can never attain; if we admit it, we reach higher and higher, until we are surprised at our own successes.

This principle is admitted in the law of our country—in our Noxious Vapours Act, the so-called Alkali, &c., Works Regulation Act, and in the Rivers Pollution Prevention Act; the admission may be inferred from the existence and phraseology of these Acts, that there are and will be pollutions of air and of water, but it is made incumbent, under heavy penalties, on every citizen to employ the best practicable means for controlling and diminishing them.

This wise position has not, however, been always taken by the Legislature. If we trace back the laws which have been passed in

reference to noxious gases, we must go back to very distant times. Five centuries and a-half ago, in the reign of King Edward II., it seems that coal ("sea-coal," as it was called, since it was brought from Newcastle by sea) was already largely employed in or about London, principally, I suppose, in smithies, breweries, and other factories where large fires were needed, not yet in houses, perhaps. It was used in sufficient quantities to cause great offence by the black smoke emitted. So great were the complaints that in the year 1313 the Parliament petitioned the King to forbid the use of sea-coal altogether; and this was done. It was a trenchant measure, and did not recognise the principle I have tried to establish, and, in consequence, it was unsuccessful. How far the edict was obeyed at the time I cannot learn, but certainly the abstinence enjoined was not practised long. Wood, the ordinary fuel of the country, became scarcer as the forests vanished before the increasing population, and coal had to take its place.

Ever since these early days, smoke has held its own against all attempts at suppression. To come down to more recent times, we find that in 1829 a Select Committee of the House of Commons inquired into the effect of the smoke of factory chimneys on the public health; and, in 1843, another Committee considered the "means and expediency of preventing the nuisance of smoke." Since that time three Imperial Acts have been passed—namely, those of 1857, 1861, and 1865—in which black coal-smoke is declared to be a nuisance, and its emission prohibited under penalties. In the Public Health Act for Scotland, 1867, black smoke is condemned as a nuisance, and in the Scotch Smoke Abatement Act, 1857, it is enacted that—"Every furnace be constructed or altered so as to consume or burn the smoke arising from such furnace." The penalties attached are from forty shillings to £5 for the first offence; £10 for the second offence; and for every subsequent offence, the penalty is to be double that of the last, with all costs in addition. This seems severe enough; surely there are no people daring enough to emit black smoke after this. Wait! there is one more line to be quoted:—"This Act is to be enforced by the Local Authority."

And do not the Local Authorities throughout the kingdom enforce it? Yes, certainly; at least, they do in Glasgow. They punish every one who emits black smoke, but they put their own interpretation on the word "emit." "Emit" is held to mean "discharge during three consecutive minutes," but this must not

occur too often, that is to say, "in the aggregate, not more than ten minutes in the hour."

The descriptive word "black" is also, I am told, literally interpreted. To draw down a prosecution the smoke must be quite black. Is not three minutes of uninterrupted densely black smoke a long measure, or an aggregate of ten minutes in the hour? It would, I think, show that no great effort had been made on the part of the proprietor to prevent smoke emission. Moreover, is a space of three minutes, or an aggregate of ten minutes in the hour, allowed for each boiler? If so, in cases where there is a battery of six or more boilers, black smoke may be sent out all day from the chimney-top without giving ground for interference on the part of the police. Let us presume the ten minutes' allowance is for each chimney, not for each boiler.

In London the police inspectors do not consider that their duty is limited to the simple observation of the chimney-top. When offensive smoke is found to issue from it, their engineer visits the factory and ascertains by his own inspection whether any and what means are in use for preventing smoke. If the owner of the furnace is earnestly applying means likely to accomplish the desired end, time for carrying out the plan is given, and much greater leniency is shown than where nothing is being done of a remedial nature. The engineer so employed under the Home Office no doubt is often able, by judicious advice and by affording information, to smooth the path which steam users sometimes find such a difficult one to tread.

There can be no need, however, for continued leniency where the emission of black smoke is permitted. Abundant proof has been given of the possibility, and in most cases the economy, of smoke prevention, and it may be safely asserted that, if a determination were come to on the part of the public and the authorities that the emission of black smoke should cease, the difficulties which have presented themselves would be found to have been imaginary, or, at any rate, such as could be overcome by the application of skill and determination.

To obtain correct information as to the efficiency of the various smoke-preventing appliances which are offered by their various inventors is not easy. One man declares that he is using a certain arrangement with great success. You look at his chimney and are delighted with the continued absence of black smoke. You make inquiry as to the consumption of coal and the duty done by the

boiler, but probably no correct information can be given—they are not in the habit of making such exact observations. Or, again, a friend using a novel apparatus, or some fresh arrangement of his furnace, assures you that not only has he entirely ceased to produce smoke, but he saves 10 per cent. of his coal. This sounds more promising, but on close inquiry you find that your friend's consumption of fuel had previously been most extravagant, and that to save 10 per cent. was a very simple matter, that, indeed, his present system affords no model for you to copy advantageously.

In order to make real advance in this matter, and to afford a fair comparison of the various systems proposed for economical firing with avoidance of smoke, one could wish that as many of them as possible should be worked in competition, one against the other, in the same place, subject to the same conditions, and doing the same work—all being done under strict scientific registration of the results attained.

Such an opportunity is not often to be found, but a proposal has lately been made that at the International Exhibition to be opened shortly in Glasgow such a scheme might be carried out. A battery of nine or ten large boilers is to be employed in raising steam to drive the machinery of the Exhibition; if each of these were fitted with a mechanical stoker, a hollow bridge, a steam blast, or with any one of the many appliances now brought forward, an accurate comparison could be made of their relative efficiency, both as smoke-preventers and as steam-raisers. An assistant-engineer appointed for the purpose would be able to register the amount of water evaporated and the coal consumed, so that a visitor would then receive the precise information needed, and which otherwise it is most difficult to obtain. Such a display of steam-furnace appliances would, I think, form a very marked feature of interest in the forthcoming Exhibition—one that would attract a large number of visitors, not from our own country only, but from all parts of the world. It would also leave behind it a permanent mark, as the report which would be issued would be of extreme value for future reference. Unfortunately, I have to add that this useful project is not to be carried out; the scheme has been discussed by those having the conduct of the Exhibition, and dismissed as impracticable. I cannot but think that they have magnified the difficulties to be encountered, and somewhat lost sight of the many advantages that would have been obtained.

One of the advantages gained by it would have been that of affording an opportunity of showing to any smoke-producer a number of furnace appliances, all of them successful in preventing smoke. The plea of *non possumus* would have been effectively taken away, since it would have been possible to point to a variety of arrangements of furnace appliances, all of which accomplished the desired end, and with an economy of fuel and boiler space.

Another and important class would also have been greatly benefited—namely, the Scotch colliery proprietors. Since most of the Scotch coal is highly bituminous and, when burnt unwisely, is very smoky, it has been rejected by many merchants in favour of Welsh coal, which is less gassy. Loud complaint was made last year when some of the vessels of H.M. Channel Fleet were anchored for a while in the Forth, because they sent to South Wales for a supply of smokeless coal, instead of using that from the neighbouring collieries. Now, had this competition of smoke-preventing furnaces been encouraged at the Glasgow Exhibition, no doubt it could have been shown that the Scotch gassy coal, if properly treated, can be burnt without producing black smoke.

Some years ago some of the Durham coal-owners carried out a series of furnace tests, for the purpose of proving to the Admiralty, and other consumers of smokeless coal, that their coals were also smokeless if burnt in a proper manner; and they showed that the duty got from the coal was greater when smoke was avoided than when it was emitted from the chimney. A similar set of experiments was also conducted at Wigan, at great expense, at the instance of the colliery proprietors there, and with the like result. In both cases the record of the experiments showed that the bituminous coals from those coal-fields could be advantageously burnt without producing smoke, and it was distinctly shown that there was loss of effect when black smoke was permitted to escape. Had this promising scheme been carried out at the forthcoming International Exhibition as proposed, the Scotch coal-owners would have been able to prove the economic value of their coal without going to the expense of special experiments. The fiat has, however, gone forth—the smokeless contest is not to take place.

I have dwelt now as long as my time allows on the nuisance arising from the black smoke which too often issues from factory chimneys. Much more might have been said descriptive of the various means available for its cure, and also of the repeated declarations made by the Legislature that the pollution of the

atmosphere by coal-smoke is an offence against the community and punishable as a crime.

I pass on now to consider the sub-divided but constant pollution carried on by the coal-smoke which issues from the chimneys of our dwelling-houses.

Living as we do in a climate in which for half the year artificial heat is necessary to our comfort, it is a matter of primary importance that we should learn how to warm the air of our houses. The method first adopted by the Highland cottar of lighting a fire of peat on the floor of his cabin was one most economical of heat. The heat given out by the fire was all usefully applied to the warming the interior of his dwelling. Unfortunately, with the heat was also smoke, and if the cottar ever wished to close the door of his hut he must make a hole in the roof for its escape. As an ornamental finish an old barrel, with both ends knocked out, was stuck on the roof—an incipient chimney stalk. This did pretty well in calm weather, but a gust of wind entering at the door so whirled about the smoke, mixing it with the air of the room, that it was no longer pleasant for eye or nostril.

Some adventurous spirit, determined in building his abode to advance beyond what his father had done, prolonged the chimney downwards, passing it along, or building it in, the house wall, and, removing the fire from the centre of the floor, placed it against the wall under the chimney prepared for it. What convulsion of society accompanied the taking of this important step in domestic economy we are not told. Probably the first innovators were placed under a ban—were shunned as those who desired to overturn society. They were iconoclasts, dishonouring the traditions of their ancestors. Indeed, this step was so painful that humanity has steadily refused to take another in this matter, and our elaborate fire-places, with their ornamental surroundings, are but the hole in the wall with the uprising chimney devised by this remote ancestor.

Much may be said in praise of the open fire. Who does not love its bright and genial blaze, or would undertake the thankless task of pointing out deficiencies in so cheery a friend? May be, indeed, the fault is ours: we expect too much of the fire, demanding of it that which can better be otherwise supplied.

To make sure that all the smoke should pass quickly up the chimney and not mix with the air of the room, we make an ample opening. This permits the passage not only of the smoke but of

a large stream of air also. The air thus taken from the room and expelled through the chimney must be supplied again; it is therefore drawn in through every crevice, through half-shut door or leaky window. Nor is it possible to avoid this in-draught of cold air, for were it completely prevented the chimney would cease to keep the room free from smoke.

The cure for draughts of cold air should not be sought by listing the door and putting sand bags on the windows, but by providing a quantity of warm air sufficient to supply all the demands the open chimney may make upon it. When the house-doors are shut and many fires are burning a considerable suction is set up by the draught of the chimneys, and if no proper provision is made for the entrance of air, air will enter at improper places, perhaps through cellars, bringing with it a damp unwholesome taint; or, may be, through an untrapped sink or faulty drain pipe; or down an unused chimney, bringing with it the unwholesome smell of soot.

A remedy for all this will be found in providing for the free entrance of air through some proper channel. In my case I have chosen the back or garden side of the house, and about 10 feet from the ground have cut a hole for the admission of a light iron pipe 10 inches diameter; this turns upwards a little towards the sky, and is protected from falling dust by a slight hood. The air passing inwards meets first a large sheet of thin woollen cloth, through which it filters and there deposits the smuts and dust too frequently found in the air of all towns. This cloth should be as large as possible so as to offer as little obstruction to the air as may be. In my case the extent is 24 square feet. From the shallow box containing the filter cloth the air passes on as before through a 10-inch iron pipe to the heating stove, the construction of which I will presently describe (see Plate VI.). There warmed to a temperature of about 150° Fah. it ascends through a short pipe to a grating in the hall. This becomes filled with warm air, and from it the adjoining rooms draw their supply. The warm air ascends by the staircase-well and finds its way into every apartment. The chimneys of the house are all open; the ventilation not only goes on as usual but is much assisted by the constant stream of warm filtered air ever driven in. There is produced an all-pervading sense of comfort. It is no longer necessary to carefully select the one or two places in the sitting-rooms which have the repute of being free from draught—all places are alike. The doors may now be left ajar

without arousing complaint, and the window is no longer accused of causing a draught.

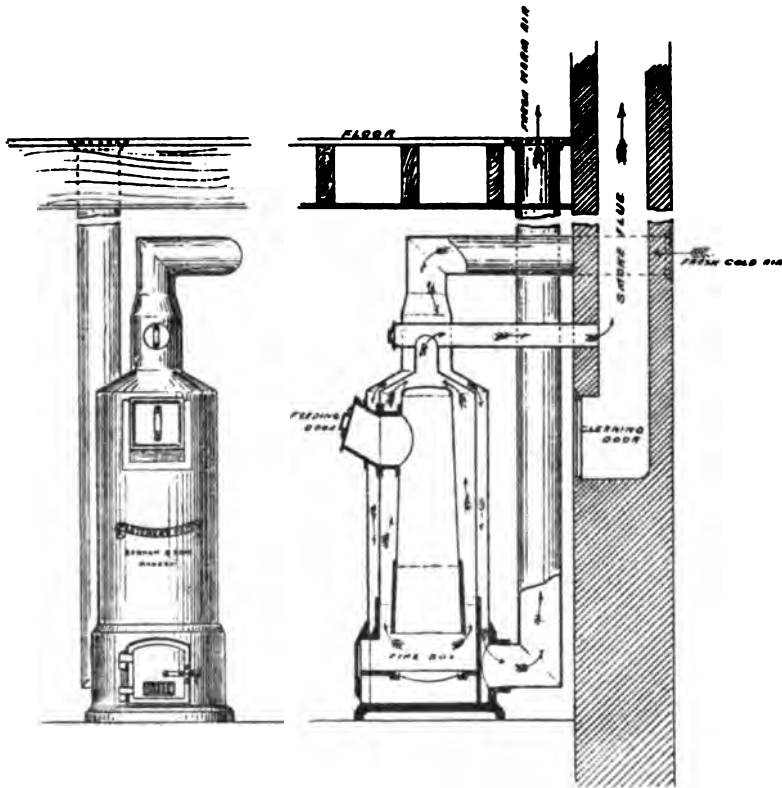
Much might be said as to the moral effect of such an arrangement in that many of the minor discomforts of the house are removed. The effect of supplying a house freely with warmed fresh air is like that of changing the climate, it is as a change of season—a leap from January into May.

Air warmed by a stove is often said to be unpleasantly dry. Yet, how has the air been dried? The heating surfaces do not absorb moisture, nor have they power to destroy it. True, the air is expanded, and therefore the warm air has less moisture per cubic foot than had the cold air. Yet, can this be an evil? The air of our climate is usually too moist, and we gladly avail ourselves of an opportunity of staying in a district where the air is dry. Why then is the alleged dryness of stove-warmed air objected to? To this the following reply may be given. The air around us is laden with dust. This is composed of filaments of cotton, wool, hair, and other matter chiefly either of animal or vegetable origin. These small particles on coming into contact with the heating surfaces are singed or burnt, and made to give out a characteristic smell. It is this burnt smell which is objected to. The air, however, is not burnt, but only the dust with which it was laden; nor is it dried, and if it were that would not be detected by the nose. It is not usual on a dry sunny day for us to say—"How unpleasantly dry the air smells."

If, then, the over-heated or burnt dust is the cause of the offence, the evil may be avoided by removing the dust. This is done by filtering the air through a woollen cloth before it reaches the heating stove, as has been already described. It is found that air so filtered before being warmed does not assume the unpleasant smell referred to in passing the stove. Of course all heating stoves should be so contrived as to have a large, moderately heated surface, rather than one small and over hot. In the drawing now shown (Plate VI.) it will be noticed that the heat is, in the first instance, taken up by the products of combustion which are made to surround the stove itself in an annular envelope. Outside this is the air to be warmed which gets its heat thus at second hand, and moderated in degree.

It will be noticed that the air to be warmed enters at the top of the stove, coming first in contact with the smoke as it leaves. Descending now it passes over surfaces progressing warmer until

HOT-AIR STOVE FOR HOUSE WARMING.



it touches the hottest part, and then ascends to pass into the house. Thus the air leaving the stove is much hotter than the smoke, it being about 200° Fah., while the smoke is about 120° Fah. This is the reverse of the condition usually experienced in air-heating apparatus. There the air and the smoke pass away in parallel channels, moving in the same direction. The smoke must, therefore, on leaving, be always hotter than the air it has warmed. In the stove here shown, the air and the smoke move in opposite directions.

The stove requires charging with coke once only during 24 hours. It burns at a uniform rate during the whole time, the rate of combustion being regulated by a small slide which limits the admission of air. A drawing of this stove is shown as one that has been found convenient and economical, not as being the only suitable one.

The principle urged for adoption is that of admitting to the centre of the house, or to the separate rooms, a liberal supply of warm filtered air, in addition to the usual open fires. For my part I use gas fires as being clean and economical, and we cook by gas, so that in my house no coke smoke is made, and we contribute no impurity to the atmosphere beyond carbonic acid, the sulphurous acid due to the sulphur of the coke. This is, however, less than was in the original coal.

If all would conduct their house-warming on this plan our towns would light up as with the smile of sunshine, and our fogs when they come would pass harmless and unstained as a country mist.

XIX. — *A Set of New Ring-off Instruments for Telephone Exchanges, &c.* By D. SINCLAIR, *Engineer, National Telephone Company.*

[Read before the Society, 16th November, 1887.]

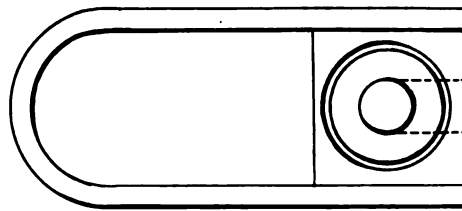
BEFORE describing the new indicator which is before you, it will be necessary for me to explain how such an indicator is required in Telephone Exchange work.

As you are aware, it is the function of an Exchange to join, as required, any two of the wires which form the Exchange. Each wire in the Exchange passes through an ordinary electro-magnet as an indicator, and in some of the older systems the two lines wishing connection were joined, having both indicators in circuit. In the later and better-arranged Exchanges the two indicators are cut out, and the connecting wire has an indicator in its circuit; thus, only one, instead of two indicators, is in circuit while the subscribers are in communication—an arrangement which improves the speaking very much.

In Telephone Exchange work it is found that when a subscriber is finished with a conversation, there has been, up to the present, no proper way of apprising the Exchange when he is finished, unless, indeed, in some towns where a separate wire is erected to each office for that purpose.

It often occurs in practice that a subscriber wishes to make a series of calls as quickly after each other as possible, so that it is important that the exchange be got in each case immediately, and, at the same time, that the party who has been finished with should not be further troubled; and it is with this end in view that the instrument before you has been designed.

The main features in the arrangement are—1st. That when two subscribers are joined together they can ring and speak to each other without making a signal of any kind in the Exchange. 2nd. Either of the subscribers so connected can cease to ring each other and has power to signal the Exchange, at the same time connecting his line automatically on to the operator's telephone, so that immediate attention is secured at all times. Any one



Magneto.

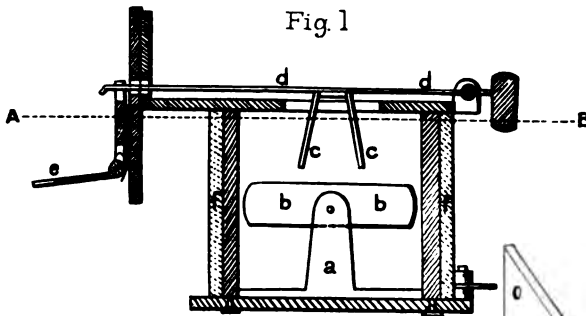


Fig. 1

Section thro. C.D.

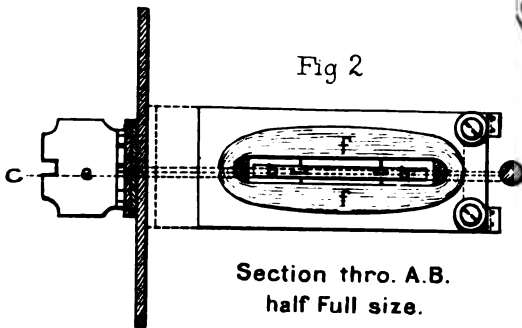


Fig. 2

**Section thro. A.B.
half Full size.**

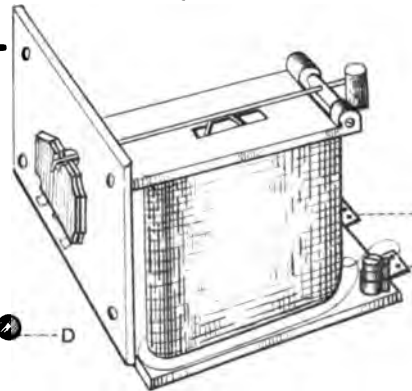
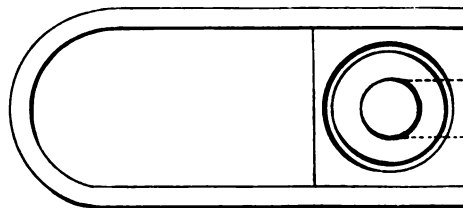


Fig. 3

Indicator.



Magneto.

asking for and obtaining a wrong person can instantly and conveniently get disconnected and put on to the proper party.

Each subscriber is provided with a magneto of the ordinary kind in use, but with the armature of the instrument commutated and provided with a switch, wrought either as a two-way or as a push-button, as in the instrument now exhibited. When a subscriber rings in the ordinary way he sends out to line alternate currents, and when the button is pushed in it brings the commutator into use and sends out to line a continuous current. The indicator at the Exchange is so made that an alternate current produces no effect upon it while a continuous current operates; the ordinary shutter falls and is employed to join the line direct to the operator's telephone.

The indicator necessary for this is of a new form, and is made up by the Western Electric Company of America in conjunction with my patent. It consists, as shown on Fig. 1, Plate VII., of a solenoid of wire, in the centre of which an upright, *a*, is placed, having a magnetic iron beam, *bb*, pivoted, so that a continuous current of either polarity will cause it to swing. Over this beam are placed two prongs, *cc*, from the armature spindle, *dd*, as shown in the drawing.

An alternate current sent through the solenoid, *ff*, Fig. 2, acts upon both ends of the beam, *bb*, at the same time, and consequently it does not swing. It will be seen that the beam moving in either way has the effect of lifting the armature spindle, *dd*, and releasing the drop of the indicator, *e*.

As well as using these instruments for Exchange purposes, it is intended by their employment to make one wire serve for two subscribers. It will be observed that by placing an indicator of this kind in the premises of the first subscriber he could be called with a continuous current which would not affect an ordinary magneto bell at the second subscriber's instrument; and the second subscriber could, with the ordinary magneto, ring the Exchange without interfering with the first, as an alternate current does not act upon the indicator. An arrangement of this kind would be especially useful in connecting up private houses or other places where the wire is not used very frequently.

XX.—*On some of the Social and Economical Aspects of the Land Question in Wales.* By HENRY JONES, M.A., Professor of Philosophy in the University College of North Wales.

[Read before the Economic Science Section, 5th April, 1888.]

It is not inconceivable that the first effect of seeing the subject of to-night's lecture will be to induce you to parody the words of Hamlet and ask, "What is Wales to me, or I to Wales, that I should weep for it?" It might seem that your economic and political wisdom is already sufficiently tried by your crofters, not to say anything of our Irish neighbours, whose problem bids fair to rival that of metaphysics in both of its great characteristics of permanence and contentiousness. But, inasmuch as a rumour has gone forth that Wales is seeking to tamper with the principles of existence in this nether world—namely, the laws of political economy and the British constitution, the politician and the economist are beginning to get curious about it.

It is not altogether flattering, either to a people or a person, to be the object of mere curiosity, but it is on the whole better than to be entirely ignored, and particularly when help is required. An outsider, knowing that nearly all the greater lights in politics have of late gone down to Wales on purpose to illumine its darkness, may think that, so far from being ignored, it has received attention quite out of proportion to its magnitude. And so it has—of a sort. But, unfortunately, it has been that sort of attention which Belgium used to get during the continental wars. Wales is becoming the political cockpit of Great Britain. The politicians are not fighting *for* Wales but *in* Wales. They go down not to learn but to teach, and the majority of them have paid to Wales the enormous compliment of treating it as if its people were perfectly altruistic and cared for everybody's affairs except their own; for they speak not of Wales and its needs but of Ireland, England, and Scotland, and Ireland, Ireland, and Ireland. There are only a very few facts about Wales of which the

ordinary English politician feels certain. Two of these are :—1st, That Snowdon is its highest mountain ; 2nd, That it is inhabited by a very good-natured and gullible people who want to starve the parsons. As it is not for me to deny anything that may seem to anyone to redound to the credit of my native land, I shall make no reference to the first of these facts, and only state of the second that it is not a fact. Welshmen as a rule only want the parsons so to reduce their stipends as to participate to some degree in that more general starvation which threatens the community and with which we have to deal.

Being neither a professional economist, nor (*laus Deo*) a professional politician, I think it may be demanded of me to give an account of the social and economical aspects of Welsh life which shall be neither biassed by an abstract and theoretical point of view, nor distorted by any ulterior ends. Having spent all my life in Wales—except a too brief period during which I was kneaded at Gilmorehill into my present intellectual shape, “if shape I have ;” having lived amongst the Welsh masses and seen a little of the classes ; having frequently sat at the farmer’s hearth and “heard him complain ;” and having also occasionally seen the land agent sorely puzzled between the rival claims of his landlord’s pocket and his own humanity, certain questions connected with the land have been pressed upon my notice, and I have not found it easy to prevent them from penetrating inwards and disturbing the placid calm of the mind which a votary of philosophy is supposed to possess. In fact, I have come, very unwillingly, to the conclusion that unless Wales is seen to more carefully, studied more sympathetically, and helped more promptly, the evils that are working within it will issue in a tragedy. I shall endeavour to state in a simple and unstatistical manner the reasons that have led me to this conclusion.

The first of these lies in a fact which neither the English parliament nor Welshmen can help : it is that the Welsh people form a distinct nation, though not an independent one even in desire, and that it is a small nation. Being a distinct nation in a fuller sense of the word than even Ireland and Scotland, having not only its own racial characteristics, religious instincts and habits, literature and past history, but also, unlike Ireland and Scotland, its own living language—separated, in fact, from the English nation by every one of the great elements that distinguish nations from each other (except hatred and antagonism), many English institutions

are either too good or too bad for the Principality.* Whether they happen to be too good or too bad is really beside the question, as everyone will acknowledge who knows anything of the development of the character of either a people or a person; for all alien institutions, just because they are alien, limit the development of a people, make demands on it which it cannot recognise as duties, and thereby instigate the strongest spirits of such a people to assert their freedom by force, more or less disguised.

Now the smallness of the Welsh nation makes it very difficult for it to enforce its wants in a constitutional manner—a difficulty which, as a little reflection will show, must increase inversely as the magnitude of the social unit. I, for one, cannot expect the imperial parliament to be so prompt in endeavouring to remedy the evils of Wales or realise its ideals as those of England, or Scotland, or Ireland, for the sufficiently cogent reason that the legislature is only an imperfect instrument, just as the “Deity” is an Imperfect Being for those people who find it more difficult to see the divine rule in the fall of a sparrow than in the courses of the stars. Government according to the will of a majority is only a very imperfect weapon of national freedom, in so far as all the wants of men are not universal wants. A highly developed political organism is a many in one, an intense unity amidst real differences; but such an organism the imperial government is not as yet, except perhaps potentially.

From these principles it seems to me to follow that there must be difficulties in the way of dealing justly with Wales, the smallest of the units which depend upon their connection with England for the most permanent and important elements of political welfare. England is permanently tempted to ignore the needs of Wales, and Wales is permanently tempted to make use of more or less disguised violence in order to reveal and emphasize its wants. But violence, however constitutional in appearance, is a very dangerous weapon. Even if Wales, following the example of Ireland, were to globulate its twenty-eight or thirty votes, and succeed in

* This is in my opinion the reason why “Disestablishment” is quite a different question in Wales and Scotland. The religion imposed by the State on Wales is alien in form; but that cannot be said of the Scotch Establishment. Episcopalianism is not the natural expression of the religious instincts of the Welsh people—perhaps because it is too good for them, perhaps also because they distinguish more clearly between spirit and matter than the English do.

securing thereby every political end which it seeks, it would have to reckon with a new and far more serious difficulty of its own creation—namely, a loosened national morality; and there is no end which justifies a people in running into arrears with morality. On the other hand, no legislature can inflict a deeper injustice on a people than, by neglecting its demands, to force it into a choice between abandoning its ideals and sacrificing its character and respect for law. And this is certainly done to Wales by the English parliament. Ever since 1868, when political life in Wales first sprang into existence in modern times, the Welsh people have demanded the disestablishment of a church which, whether the best or the worst in the world, it certainly does not want; they have demanded this with a unanimity and persistence to which Ireland can offer no parallel; they have really voted at the elections on no other issue, for it is Episcopalianism and dissent that mainly constitute the conservatism and liberalism of Wales; and they have done this in vain. Or, to give a less contentious example, Wales has for many years demanded from the legislature a system of secondary schools, the means of better education, for which it is willing to pay, and which any cultivated people ought at this time of day to be prompt to grant, even to eagerness, but they have demanded it in vain; even the relations of men with their deceased wives' sisters yield no such example of ineffective dalliance as the promising, introducing, withdrawing, improving, re-introducing, and re-withdrawing of the Welsh Intermediate Education Bill. Wales is small, and it is very hard for it not to believe that it must brutalise itself and become Irish in order to attract the attention of the English parliament; and if it does eventually follow the footsteps of its western neighbour, it must not be forgotten that for many years it has been lashed into that course by the indifference of the English, Scotch, and Irish politicians.

There is, however, one conceivable way of avoiding this disastrous issue: it is by increased energy on the part of Wales in making known its condition, and by increased readiness on the part of the imperial parliament to be instructed with regard to the Principality. Welshmen as a whole do know what they want better than other people do, but they should recognise that it is incumbent upon them to prove to the English parliament that what they want is legitimate. In my opinion, "Give it them *because* they want it" is as iniquitous as its opposite, "Give them

nothing at all or nothing except that which we ourselves want." The imperial parliament is able and willing to consider just claims, although the willingness is rather stolid and inarticulate, like that of "Mr. Barkis." What is required is more discussion, more light on Welsh affairs; and were it not for one thing we might trust this peaceful and effective, though slow, process.

That one thing is that Wales cannot easily wait for this slow process, for a new and more imperative need is fast pressing into the forefront in its social history: it is the need of means to live on the part of the agricultural community and all that depends upon it in the Principality. Wales, no doubt, has wonderfully strong religious and educational instincts, but the instinct for food is still stronger there, as elsewhere; and unless every symptom of agricultural and financial distress be falsified, it is *not possible* for Wales to wait so long for legislative reform in its system of land tenure as it has done for reforms in these other matters. The deafness of the English parliament on the one side and the littleness of Wales on the other constitute in this respect the elements of a real tragedy. A community always poor, as compared with the similar communities in England and Scotland, it is becoming much poorer year by year, and unless it gets external aid it cannot extricate itself out of the gravest difficulty into which any people can fall.

What, then, is the state of Wales, you naturally ask, as compared with the crofters, or the Irish tenants, or even the English farmers?

This question it is my duty to try to answer, but not in this form. Not in this form, because, in the first place, I have not the adequate information to make a comparative statement; and, in the second place, because, if I had such information, it would not help me or you to form a true opinion of the Welsh land difficulty. I wish to emphasise this point in passing, because, although it is frequently admitted in theory, it is generally forgotten in practice that every economical problem ought to be studied, not by reference to similar economical facts elsewhere, but by reference to the peculiar character and social conditions of the particular people. If you could prove complete similarity in the external conditions of existence of the Welsh, the crofters, the Irish, and the Lowland farmer, you would not be able merely on that account to pronounce a judgment as to their needs. Dugald M'Tavish and John Jones may be equally poor, but if they are

different in character the one may be crushed by his poverty while the other may find strength in it. I am not willing to say that politics and economics have no fixed principles; nor is the English legislature altogether degraded into mere opportunism—a shuffling of cards by an old hand. But the principles which they contain are relative not only to human nature but to the particular forms which it assumes amongst different nations, and which are expressed in their institutions. Political economy is not the science of wealth, but one of the sciences of man; it is the science of man in relation to the satisfaction of his needs and the expression of his character through natural products. This is recognised by the modern school of economists. Unrestricted competition is not now credited with a tendency to produce harmonies except at a certain stage in the development of a community. Its value is relative. It may be the very best thing possible to permit the lowland Scotch “to fight it out” in agriculture as in other things; the tenants may not improbably be quite able to hold their own. But this does not prove that legislative interference with agricultural contracts is not necessary for Wales, or for the Irish. Tenants like the Scotch, who were able to extort leases from their landlords during the “good times,” will probably refuse to be crushed when times are hard; while tenants like the majority of the Welsh, who rented their farms year by year when produce yearly increased in value, are not so likely to enforce their rights during bad times. The question of legislative interference with unrestricted competition is relative to the character as well as the condition of the parties to the agricultural contracts in Wales, Scotland, Ireland, and England. In fact, all legislation is thus relative. Its task is to let every people, so far as possible, realise its legitimate needs and be what nature has intended it to be, and not lay it on any Procrustean bed, even though that bed be adequate to the burly form of John Bull.

The land question in Wales thus seems to resolve itself into a comparatively simple question of fact. Are the landlords and tenants in Wales of such a character, and placed in such social circumstances, as to permit them without external interference to secure their respective rights by contract? Is the rent fixed by competition such as is advantageous to both parties to the contract?*

* I do not wish to discuss any of the broader and more revolutionary questions, such as the justice of paying any rent, and of private ownership in land.

I say "to *both* parties," because it is evident that excessive rent will lead ultimately to robbing the soil and the impoverishment of the landlord as well as the tenant. Now, if the rent is even proximately just as fixed by competition, then it would be positively injurious to interfere with the system, for although the collision of private interests is not the highest conceivable form of commercial relationship, still it lies on the direct road of national development. It secures in the long run a firmer basis for social welfare than any of the hasty Socialisms, which are so greedy for quick returns as to deprive individuals of their means of independence in order to prevent injustice. The developed State will consist of individuals who freely give themselves to the service of the whole, and who therefore have *selves* to give; and although morality ought not, like political economy, to fail to distinguish between persons and private property, still private property is a condition of the higher freedom, as both history and philosophy can prove.

But in order to secure this end, the contract must *be* a contract. It must not be legalised coercion, or a "sweating system," which adds to the wealth of the employer of labour by sapping the foundations of industrial success, and destroying the great productive implement, viz., the human worker, as well as the social structure which he upholds.

Now, I hold that in Wales, taken as a whole, the agricultural tenants are rapidly sinking into such a state that the contracts which they form with their landlords are like the "sweating system," a species of immoral contract, which legislative recognition cannot render ultimately valid.

The Welsh tenants (to put it as simply as possible), owing to the action of peculiar circumstances upon a class of people too weak to face them and force good out of them, have undertaken to pay, and continue to undertake to pay as rent, more than it is possible for them to pay. I say explicitly "continue to undertake," for it is well known that in the Principality, as in Ireland some years ago, we have the curious phenomenon of the keenest competition amongst tenants for vacant holdings, although it is at the same time recognised that similar farms let on similar terms bring annual loss to their occupiers. This is one of the considerations which increase the difficulty of dealing with the matter. It prevents the landlords from recognising the seriousness of the aspect of agricultural matters, and tempts social reformers

to believe that there is no way of stepping between such tenants and the fate they deserve.

But, as already hinted, it is the incapacity of a portion of the people to secure their own welfare and that of those who depend upon them which makes it imperative on the legislature to step in to their aid. It is *because* we cannot leave the crofters, the Irish tenants, factory children, degraded humanity in the city slums, at the mercy of the positive checks of natural law, that we form laws of our own for their protection, while we leave capable humanity to itself. And it is because of the excessive land hunger, characteristic of the Celts in Wales, as well as in France, Ireland, and the Highlands, which leads the tenants to bargain imprudently, and even disastrously, for farms that external help is needed. This imprudence of the Welsh farmers is, in fact, an argument against, and not for, leaving rent to be fixed by open competition.

From this it follows that the force of the demand for a Welsh Land Act does not arise, as is generally taken for granted, merely from the poverty of the tenants, but from the more general condition of the agricultural class of which that poverty is only a result. The amount of poverty is not a measure of the necessity or justice of legislation, but of the *immediacy* of the demand. It is, comparatively speaking, a matter of little importance that the farmers in Wales have become very poor and are annually becoming poorer; the sting of the evil lies in the fact that neither in the state of agriculture, nor in the character of the Welsh tenants, is there any promise of ability to extricate themselves out of difficulties which are not only growing, but which they themselves increase, *voluntarily*, so far as people in the power of circumstances do anything voluntarily. Let me illustrate this point. "When times were favourable" (says the author of the admirable little book on "The Land Question and a Land Bill with special reference to Wales") "the Welsh farmers saved money if it was possible to do so; for they are exceedingly frugal, and habitually stint themselves to a degree unknown amongst the same class in England. But the great depression, which was first severely felt in 1879 in the counties where the farmers depended mainly upon live stock, and which has been increasing in intensity year by year, has long ago swept away the savings of a large proportion of the farming community. Even in Anglesey this will be found true, although there the condition of agriculture is

as favourable to the farmer, if it is not more so, than it is in any other county in Wales. But the evil has not rested with the loss of the savings of the past. During the last three years many of the farmers have sunk deeply into debt, although not with the landlords as a rule; for the Welsh farmers are so timorous in their dealings with the landlords as a rule that in order to pay the rents they have had recourse to methods as unwise as they are desperate. They have let their other debts accumulate; they have borrowed money at exorbitant interest; they have reduced their stock; they have taken all they can out of the land and put in as little as possible; they have half-starved themselves and their families." I should like to emphasise every sentence in this paragraph, for it is an account as true as it is graphic of the condition of an increasing number of Welsh farmers. Many of them are absolutely poorer than the day labourers whom they employ; some of them live on such hard fare that their servants refuse to continue in their service. In many cases you can measure the growth of their poverty by the increasing raggedness of their clothing, which they are not able to renew. I could tell you of farms where parents and stalwart sons and strong daughters labour hard from year to year for something less than no wages at all. The oldest and wisest men in the rural districts have never seen the country so poor. There are parishes I know in which not more than from three to six of all the tenants are able to pay their rents without having recourse to ruinous loans. The village blacksmith, shoemaker, tailor, shopkeeper can neither get paid for the work they do for the farmers—work reduced to an absolute minimum—nor can they do without it. A country tradesman takes a bill of £5 or £7 to a farmer, willing to pay if he only could, and must content himself with present payment of 7s. 6d. or 5s., with promise to pay more "as soon as possible." I know, of course, that such people as these ought to give up their farms, and that it would be far better for most of them to become farm labourers; but it is well known on the other hand with what ruinous tenacity people cling to the semblance of a respectable position rather than fall into a lower social status. The simple fact is that they will not give up their farms before they are ruined, for to give up farming would be their ruin, seeing that they have no other outlook and no capital to put into any other business; nor will they emigrate, for they cannot; and, worst of all, they will not combine peaceably so as to create

a will sufficiently strong to cope with that of the landlord, for they are too timid. They cannot save themselves, nor can they confine the ruin which their weakness creates to their own class. The rural districts as a whole are travelling fast along the road to squalid poverty.

Now, it is naturally asked how it comes about that the owners of the soil are so ignorant of their own interests as to permit matters to come to this pass. And this will lead us to consider another peculiar aspect of Welsh life which complicates the Welsh land problem. It should be stated, in the first place, that there is no ground for the opinion that the owners of the Welsh soil are worse than others of their class elsewhere *as men*; but it is far more difficult for them to do their duties to their tenants than it is for Scotch or English landlords. I can go farther, and say that some Welsh landlords have, when their circumstances are considered, dealt *generously* with their straitened tenants. But admitting that Welsh landlords are as good as, or, if you will, even a little better than, other landlords—by no means forgetting the voluntary reductions and remissions of rent that have been made,—it must still be said that the Welsh landlords as a whole cannot be expected to, and emphatically will not, save the agricultural community from ruin. The main reason of this is their ignorance of their tenants' affairs, arising from the practical absenteeism of a great number of them. I say *practical absenteeism*, for those of them that live in the country have, speaking generally, no means of directly communicating with their tenants; and the media through which communication takes place are often *distorting* to a degree which is both disastrous and disgraceful. I believe that those who know Wales best would all agree in stating that the most dangerous feature in its social life is the chasm which separates it into two antagonistic sections. The landlords are on the whole English by education, sympathy, speech, form of religion, and descent. They are in the country, and not of it; they live on it, and not for it; their *rights* are against Welshmen, their *duties* are towards Englishmen. Politics, religion, commercial interests bring the two classes together, but only to collide. Let me illustrate this, for I think it of first-rate importance to a real understanding of Wales as distinguished from Scotland and England.

A comparatively new phenomenon has recently appeared in the Principality, as significant as it is interesting. It is the sentiment of patriotism. The Welsh are very rapidly learning

to take pride in, and to be affectionately attached to, their own country and its institutions, language, and literature. You may think that both the pride and the love are irrational, or at least that there is in Wales very little either to be proud of or to love. It may be so, but the fact remains; and in virtue of it, as well as of the curious fact that this smallest segment of the Celtic inhabitants of Great Britain and Ireland, the one most immediately connected with England commercially and spatially, has retained its language, while Ireland and the Highlands have lost theirs, a new force has been generated with which the legislature must ultimately deal. Now you are well aware that love for Scotland does not now imply hatred of England, and that the British Empire may well be "an organism of organisms." Such is certainly the case in Wales also. But whereas every Scotchman worthy of the name—be he Liberal or Tory in politics, whether he founds his religious hopes on an Established or on a "Free" church—clings to his native country as his own, the love for Wales is confined almost absolutely to the Liberals and Dissenters. This "bit of sentiment," if you like to call it so, is at the same time the effect of past antagonisms, and destined to be the prolific cause of future ones. On one side you have got a landlord class, with whom the Established clergy always go, desirous of seeing Wales absorbed in England. They respect none of its idiosyncracies; its language they will not learn; its religious sentiments they will not respect; its political aspirations, whether for a better education, or for more equitable land laws, they seek to crush. I have never known Wales show a united front on any question; I have never known the Established clergy take the side of the people. The two classes in the community educate their children in different schools; they deal with different shopkeepers; their social gatherings are mutually exclusive; they fight in two compact and mutually distrustful bodies in the election of a medical officer for the poor, as in the election of a parliamentary representative. This antagonism is too often carried into a degrading use of material advantages as means to religious and political proselytism.

No one can deny that, taking the country as a whole, it is easier for a Churchman and Conservative to obtain a farm, a factorship, or any other office of trust than it is for a Dissenter and Liberal. There are thousands of good people in Wales who are forced by this miserable narrowness of the upper

classes, and their antagonism to everything characteristically Welsh, to choose between their means of livelihood and their political and religious convictions. The inevitable result has been to weaken the moral fibre of a large portion of the Welsh community. Its highest virtues are passionate enthusiasms and not a persistent sturdy strength; its lowest vices are those of weakness, sycophancy, servility, tale-bearing, petty lying. To Wales there was necessarily left from the past the legacy of a conquered people; but there has been an unbroken heritage of authority which was never transmitted from English dependents to Welsh leaders; even yet the native Welshman is a hewer of wood and drawer of water to aristocratic aliens—not in language and religion and race only, for that is nothing by itself, could it go by itself, but in sympathy. Because the landlord class have cared so little for Wales so long as they obtained from it their rents; because they have done so little for its religion except in the way of proselytism; because they have done hardly anything—higher up than the church schools—to foster its desire and improve its means for higher education; because they have never entered into any of its national aims, they have made themselves incapable of understanding what is best in Welsh life, they have withstood the realisation of its best aims just in proportion as they were national and therefore not altogether English, and they have, in consequence, willingly or unwillingly, become instruments for degrading the Welsh people into servility. How, for instance, are we to account for the notorious fact that Tory agents in Wales during general elections so over-estimate the chances of their candidate, while the Liberal agents will predict beforehand with wondrous accuracy the number of votes that they will obtain? “It is because the Welshmen are liars,” say the former. “It is because they dare not face the consequences which the aristocratic class have taught them too well to fear,” is the reply. Respectable farmers, independent in character but not in position, are compelled to remain passive during election times, and to take no public part in contests where their dearest convictions are involved, and when every instinct of self-respect urges them into activity. The Welsh farmer, being nearly always a yearly tenant, is completely dependent upon the favour of his landlord. He knows that if he does his duty and acts a manly part his livelihood is in danger; and the agents, sub-agents, and Tory canvassers are not slow to remind him of this, as well as of the advantages that would accrue to him if he took his

I have seen him in the time of his trials, he yields to the temptation,
 and I shall be sorry to see him ever if he is despised; his son's
 success in the race is well known, and his application, or that
 of his son, will receive favourable consideration. I shall be sorry to see him again, his children's
 success in the race is well known, I have known farmers, honest
 and industrious, who have been driven from life amongst their
 own people, and who have been driven during election and vote
 buying, to the point of the great sin. It is easy to lift one's
 hand against the oppressor, but what of those who
 are in the hands of the oppressor, and who are daily oppressed
 and in the hands of the oppressor.

[illegible]

The same distinctions which have succeeded in drawing the eyes of England on France are just the first intimations of agricultural progress—and those who accuse us of it are merely the outcome of failure in the English system simply misinterpreted its character. Of course the French farmers are a mass in the same the Englishmen—they are Protestants. But I believe that they would never show resistance to the law, justice or otherwise, were they not driven to it by poverty. They *will* pay both the landlord and the parson, and they are learning to fight the former by practising on the latter. Like the Frenchman who began to help the great Revolution by throwing a small boy in the streets of Paris. If it is merely antagonism to the Church now will the fact be accounted

for that resistance to the tithes follows the path of the deepest agricultural distress, and goes before the formation of district farmers' clubs and a kind of Welsh league?

It is a pitiful spectacle this, of a peaceful people moving so surely towards bitter intestine conflict and social disorder from want of closer union and the good understanding which comes from mutual sympathy between the landlord and the tenant classes. And it seems to me that a stronger case for early legislative help can scarcely be conceived.

It has not been a pleasing task for me to expose the wounds of my native land. It would have been much more agreeable to speak of the attractive elements in the Welsh character; its artistic tendencies, its gentleness, its kindness, its idealistic traits, on which Mr. Matthew Arnold used to dwell. The Celt is always prone to sniff the air rather than deal stubbornly with hard matter in the material downright spirit of an Englishman. He has not the strong back and the rigid utilitarianism of the Scotchman, but he has a susceptibility to education and a love of poetry and music which I think you cannot rival. And if England and Scotland could but avert the danger that comes from the material side, and help Wales to realise the type that is written in its blood by removing the ills against which it is too weak to battle, I can easily conceive it as repaying the empire by a service, humbler in degree, but not different in kind from that which Greece gave to Rome. But it is hard for a Welshman to escape the illusions that rise from his blood, and it is better, perhaps, to appeal for help to Wales on the ground of simple justice and the hardest commercial utility, than on the promise of any ideal repayment in the future.

THE NATIONAL BANK Act. BY ARTHUR S. McLELLAND, C.A.

Read before the Finance Committee, 6th February, 1888.]

THE CONSTITUTION of the United States of America provides that "Congress shall have power 'To coin money, regulate the value thereof, and of foreign coin,' and that 'No State shall coin money, emit notes, or issue of bills anything but gold and silver coin, and render it payment of debts.' The power of regulating banks and the issue of paper money was not, however, reserved to Congress, and is therefore under the control of each State. Where a State made its regulations there was free banking, and banks could issue paper money, while even in those States which made laws regulating the issue of paper money, these were not of a character to provide adequate security for the payment of the notes.

The notes issued in the State did not circulate, except at a discount in other States, nor sometimes beyond the district in which they were issued. In 1815 the President, in his Message to Congress, drew attention to the great inconvenience experienced from the want of a uniform national currency, and it was proposed to remedy this evil by establishing a new Bank with such ample funds as would give universal confidence, and thus induce a free circulation in every part of the United States. The result was the Incorporation of the Bank of the United States in 1816—capital \$20,000,000, of which \$7,000,000 was subscribed by the United States, who nominated five out of the twenty-five Directors composing the Board. In 1830 the circulation was \$16,083,894, and the specie in hand \$9,043,748. McCulloch, writing in 1831, says, "The establishment of the Bank of the United States has been of material service by affording a currency of undoubted solidity readily accepted in all parts of the Union."

In the year following, General Jackson, the President, vetoed the Act renewing the Charter. This was followed by an excessive issue of notes by old banks, and also by new banks, which sprang

up in almost every village. The effect is thus described:—
 “When there are so many separate and independent banks (1,400) the sphere of the influence and circulation of each is necessarily circumscribed, and when notes get to a distance from the place where they were issued, especially when they get into a different State, they circulate with difficulty and generally at a discount. Lists of banks are published with the rates of discount at which their notes are current, without which no traveller can leave his home and no shopkeeper can venture to transact his business.”
 Combe, writing in 1839, says:—“Working men also complain of another grievance. There is no arrangement by distant banks for redeeming their currency in Philadelphia, and in consequence their notes are not received by the banks of this city. The only way of disposing of them is to carry them to the exchange brokers, who buy them at a discount corresponding to the distance and difficulties of sending them to their own head-quarters and of obtaining Philadelphia money in return. Workmen complain that their masters buy up these notes at a discount and pay them over to them at par.”

It is told of a Scotch merchant in Chicago of considerable wealth, that he much increased it by starting a bank in an obscure village in one of the Southern States, and taking its notes to Chicago and putting them into circulation there—he being always willing to redeem them at a reasonable discount.

In 1861, at the commencement of the Civil War, it is estimated that there were \$200,000,000 of bank notes in circulation, of which \$150,000,000 were issued by banks in the loyal States. The necessities of the war early compelled the Government to borrow \$50,000,000 from the New York banks, against which they issued “Demand Notes,” which were not at first a legal tender. (Outstanding at 30th June, 1886, \$57,445.) In 1862 an Act of Congress authorised the issue of \$150,000,000 Treasury Notes, which were declared to be a legal tender, except for customs and interest on the national debt. The next year an Act was passed “to provide a national currency by a pledge of United States Stocks, and to provide for the circulation and redemption thereof.” By this Act a company of not less than five persons, on satisfying the Comptroller of Currency of certain requirements as to capital, and on forwarding an amount of United States Bonds to the Treasury, received in exchange “currency circulating notes” to the extent of 90 per cent. of the

bonds. The tax on this bank was fixed at 1 per cent., and a tax of 10 per cent. was put on the issue of all other banks. The natural consequence was that all the existing banks issuing paper money became National Banks, and the currency over the whole States became uniform. The limit of notes issued under this Act was \$300,000,000. As long as the rate of interest on the bonds continued high (6 per cent.) the business was very profitable to the banks, but now that the interest has been reduced to 3 per cent., they find it no longer profitable, and a gradual redemption of the notes is going on. At 21st January, 1888, there were in the Treasury \$7,024,551 notes of the National Banks in process of redemption. At 1st January the United States Treasury had been paid "lawful money" to redeem National Bank notes which were not yet presented—

From banks reducing, -	\$45,452,211
„ „ liquidating, -	55,418,563
„ Security from banks failed, -	1,037,882
	<hr/>
	\$101,908,656

The annual percentage of redemption is 25·22, so that it will be four years before these notes are all out of circulation. There has been no default by a National Bank in payment of their notes—the bonds deposited by those who failed in 1873 covering the notes issued by them. During the war the States continued the issue of Treasury "Demand Notes," which in 1864 amounted to \$447,300,203. (In circulation January, 1888, \$346,738,120.) These bear that the United States will pay "Bearer Five Dollars," and are endorsed, "This note is a legal tender at its face value for all debts, public and private, except duties on imports, and interest on the public debt."

In 1873 gold was declared to be the standard, and specie payments were resumed. A question now arose whether the Treasury, after they had redeemed the legal tender notes in gold, could reissue them, and the question was tried before the Supreme Court. Their decision seemed to be that Congress had no power to authorise the issue by the Treasury of notes, even if payable in gold on demand, but they held that the reissue of notes authorised by the Acts of 1863 was lawful, being only a continuation of an Act forced on the nation by the Civil War.

so notes, therefore, bear on their face a reference to the Act

under which they were first issued, a note issued in 1880 having marked on it, at the side, "Act of March 3rd, 1863."

In 1878 what is called the Bland Bill was passed, at the instance of "the Silver Ring of the West," which directed the Treasury to purchase silver to the extent of from \$2,000,000 up to \$4,000,000 worth per month, to coin it into silver dollars, and to issue Certificates for the amount of dollars coined. Originally these Certificates were not to be of less amount than \$20, but recently the denomination or limit has been reduced to \$1.

The Certificate is as follows:—

"This certifies

"that there has been deposited in the Treasury of the United
"States

"One Silver Dollar,

"Payable to Bearer on Demand,"

and is endorsed—

"United States Silver Certificate."

"This Certificate is receivable for Customs, Taxes, and all Public
"Dues, and when so received may be reissued."

It has been said that this Certificate is a legal tender, but I think that is doubtful. The endorsement on the Treasury Note declares it to be a legal tender "except for customs and interest on the public debt;" on the Certificate there is no declaration that it is a legal tender, but one only to the effect that it is to be "receivable for customs," &c., which the note is not. Whether the Certificates are a legal tender or not, they circulate freely at the par value, although if they represent merely one dollar in silver they are worth only 70 cents. Prior to the passing of the Bland Bill, the parties who promoted it had a Bill passed directing the coining by the Treasury of what is called a "Trade Dollar," that is to say, a dollar of the exact weight and fineness of the Mexican dollar, which it was hoped could be exported to China; but, unfortunately, the Chinaman would not have it, and "Trade Dollars" remain in hand to the amount of \$6,695,000. Some years ago a considerable number of these were in circulation, and were a source of annoyance to strangers who innocently took them as change, and found they could only be passed for 70 cents.

This "Trade Dollar" is by weight of silver worth almost eight cents more than the currency dollar, and the market price at present is 74 cents; so that for \$740 Silver Certificates you can purchase 1,000 dollars of superior value.

were outstanding at 21st January, the gold coin and bullion being \$306,203,459.

If doubt were in the least felt as to the Silver Certificates it would appear in the payment of the Custom duties, but if we take the duties in New York, amounting to \$718,000 we find these were paid in—

Gold,	-	-	-	-	\$4,000
Notes,	-	-	-	-	45,000
Gold Certificates,	-	-	-	-	566,000
Silver Certificates,	-	-	-	-	103,000
					<hr/> \$718,000

If the payments had been made in the proportion in which the Gold and Silver Certificates were outstanding, there would have been paid in gold \$243,705, and in silver \$425,295.

The paper money in circulation at January, 1888, was as follows:—

National Bank Notes,	-	-	-	\$267,051,662
„ „ Gold Notes,	-	-	-	227,734
United States Demand and Legal				
Tender Notes,	-	-	-	346,738,121
Gold Certificates,	-	-	-	96,734,057
Silver Certificates,	-	-	-	176,855,483
				<hr/>
Total Paper Money,	-	-	-	\$887,607,057

But, as I have already stated, the Treasury holds \$100,908,656 of cash to redeem National Bank notes, and as this will take about four years to accomplish, the void in the circulation may be filled by the Silver Certificates, and a crisis postponed. But who must ultimately bear the loss of the difference between the face value of the Certificate and the gold value? The United States would say that they were not liable, as they only agreed to deliver what was deposited with them, a standard silver dollar; but, if it ever comes to a depreciation of the Silver Certificates, from so many being interested (in fact everyone in the States would hold them), the Congress would take them over at gold value. But what would be done for the want of currency? The people prefer notes to gold; and the silver dollar they won't have, although quite willing to take the Certificate.

XXII.—*On an Improved form of Seismograph.* By THOMAS GRAY, B.Sc., F.R.S.E.

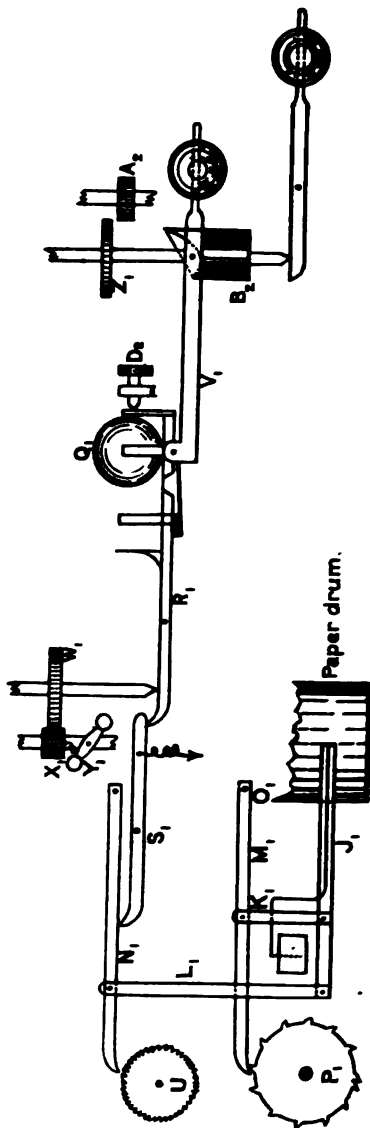
[Read before the Society, 22nd February, 1888.]

I.—GENERAL DESCRIPTION.

THE instrument which I have now the pleasure of exhibiting to this Society has been gradually developed from one of a similar kind which I exhibited here about five years ago. This instrument differs in almost all its details from the one then exhibited, but the pendulums which actuate the recording pens are the same in principle as those which were then used. The record of the motions of the earth during the transit of an earthquake are obtained in the form of three rectangular components. Two of these components are horizontal and the third vertical.

The horizontal components are recorded by means of two pendulums which consist of a mass, A, Figs. 1 and 2, Plate VIII., fixed to a rigid rod, B, the end of which terminates in a vertical knife-edge and rests on the bottom of a flat steel V-groove, C, fixed to the pillar, D. The weight of the mass, A, and the rod, B, is supported by a steel wire, E, attached at its lower end to a stirrup, F, forming part of the mass, and at its upper end to a small drum, G, which can be turned by means of a worm-and-pinion, so as to adjust the level of the rod, B, until the knife-edge rests fairly on the bottom of the groove, C. The wire, E, passes over a V-pulley, H, before it reaches the drum, G, and this pulley is mounted on a spindle which can be screwed backwards or forwards in the direction of its length, so as to adjust the position of the pulley until the top of the wire is vertically above the groove, C. The mass, A, can be moved to any position on the rod, B, and by this means the sensibility of the instrument can be varied to suit the motions most prevalent in the district where it is being used. When the mass, A, is used very near to the knife-edge at C the force holding the knife-edge against the bottom of the groove is small, and, to avoid any chance of its being thrown out of contact by the shaking, a spring, I, Fig. 1, is connected by hooks between

Fig 3



Machine-Mounted & Co.

a stud attached to the rod and a knife-edged eye attached to the pillar. In some of the later instruments this spring is kept continuously in position, the stud being fixed a little to one side of the rod, B, and a screw adjustment adapted to the knife-edge, so that by altering the pull on the spring the azimuth of the rod, B, can be adjusted. When this mode of adjustment is adopted two pillars, D, are fixed to the sole-plate at diagonally opposite corners, and the free ends of the rods, B, with the masses, A, nearly meet at the corner occupied in this instrument by the pillar. A somewhat simpler form of attachment can then be used on the top of the pillar, and the relative motion of the mass, A, and the earth, is transmitted to the writing pens by means of fine wires kept taut by light springs, the forces of which balance the pulls of the springs, I. The connection between the rod, B, and the writing pens, in the form here shown, consists of a light tubular rod, L, which is hinged near the knife-edge end of the rod, so as to turn in a plane, making an angle of about 45° with the plane of the deflected pendulum. On the free end of this connecting-rod a steel cone is soldered, which passes over a needle-point forming part of a small block which can be slid up and down the vertical arm of the bell-crank shaped levers to which the siphon pens are attached. By sliding this block up or down the ratio of the magnitude of the record to that of the actual motion can be changed. The sensibility of the instrument to horizontal motion can thus be changed either by changing the position of the mass, A, on the rod, B, or by changing the position of the needle-point on the vertical arm of the siphon lever. Excessive deflection of these horizontal-motion pendulums is prevented by Y-shaped guards fixed to vertical rods, which slide in the pillars, MM, and which, by varying their height, can be adjusted to give any desired range of motion to the rods, B.

The vertical component apparatus consists of a cylindrical mass, N, adjustably fixed to a rod, O, which is supported in a horizontal position by means of two flat springs, PP, and an axis formed by two knife-edges, Q, which rest against the top of two A-grooves. The springs, PP, are of uniform thickness, but are of such a breadth at different points of their length, that when supporting the weight of the lever, O, and the mass, N, they bend approximately into a circular form. They are attached at their lower ends to blocks, RR, fixed to the pillars, SS, and at their upper ends they support the lever through a series of knife-edged hooks designed to give

stability and small friction. The quality of the knife-edges on the cross bar, T, which forms part of the lever, and at the points of attachment of the supporting springs is important, as, if they are bad, they may cause the lever to vibrate with a comparatively short period for oscillations of very small amplitude. In order to render the free period of oscillation of this horizontal lever long enough to prevent any disturbance in the record due to oscillations of the recording lever, the point of attachment of the springs to the lever is placed between the mass, N, and the line of the knife edges. The effect of this arrangement in lengthening the period will be understood from the following simple case, which is near enough the same as that adopted in practice. Suppose the lever to be rigid and massless, and the moment of inertia of the mass, N, round the axis of the lever to be simply $N \times l^2$, where l is the distance of the centre of gravity of the mass from the axis. Let also l be the distance between the point of attachment of the spring and the axis, $L \phi$ the couple required to turn the lever through the angle ϕ supposed small, and μ the moment of inertia of the mass, N, round the axis of the lever. Then the equation of motion is—

$$\frac{d^2\phi}{dt^2} = \frac{L \phi}{\mu}$$

or if T be the period of oscillation—

$$T = 2\pi \sqrt{\frac{\mu}{L}}$$

Now, as l is increased and N diminished, the product remaining the same, we have $N l = \text{constant}$, = C suppose, and $\mu = N l^2 = C l$.

Hence $T^2 = 4\pi^2 \frac{C l}{L}$, or the period increases as the square root of l increases. By the arrangement of springs adopted in the instrument the couple, L, is made small, and the length moderately great, while still retaining moderate dimensions for the apparatus, which is the chief object in view. In order to still further lengthen the period of oscillation two spiral springs, U, the lower ends of which are attached to adjusting screws, V, near the bottom of the pillars, S, are hooked to two eyes in the ends of the cross bar, W, which is vertically above the line of the knife edges, and at an adjustable distance from them. The effect of these springs is, as it were, to add negative stability to the arrangement. Suppose the lever to be deflected downwards, then the line of action of the

spiral springs comes in front of the axis, and they introduce a couple tending to increase the deflection, and similarly when the lever is deflected upwards they introduce a couple tending to increase the upward deflection. Hence, if the pull on these springs and their points of application be properly adjusted, the lever will be in nearly neutral equilibrium, that is, the period of free oscillation will be very long. Let the modulus of the supporting springs be M , and the arm at which it acts a ; let the modulus of the compensating spiral springs be M_1 , and the height of their points of attachment above the axis of the lever a_1 . Then for a deflection of the lever equal to ϕ we have, on the supposition that the lengths of the compensating springs and links are great compared with a_1 , for the return couple, $M a^2 \cos \phi \sin \phi - M_1 a_1^2 \cos \phi \sin \phi$, where $b \times a_1$ is the total elongation of the spiral spring when the lever is horizontal. Now, in order to obtain perfect compensation, the rate of variation of the compensating couple must be the same as that of the supporting couple. Hence we must have $M_1 b \sin \phi = 0$, or the total elongation of the spring must be a_1 . The distance a_1 is made adjustable so that $M a$ may be made equal to $M_1 a_1$ if desired.

The record-receiving surface consists of a band of thin printing paper, which is held on a supply drum, shown at X. From this drum the paper passes round a cylinder, Y, Fig. 2, which is in gear with the clockwork train, and thus governs the speed at which the paper is fed forward. It is then wound up on a haul-off drum, Z, Fig. 2, which is turned by a separate train of wheelwork actuated by a weight. This arrangement avoids all trouble with regard to change of the speed of the paper, in consequence of the increasing thickness of the drum on which it is being wound. The rate at which the cylinder, Y, is kept turning is under ordinary circumstances about half an inch per minute. This is sufficient to give the time of occurrence of any disturbance with sufficient accuracy, and is still slow enough to allow one roll of paper to last for several days. After the paper runs through, the supply and haul-off drums are interchanged, and the paper allowed to run back again, writing on the other side. This may be repeated several times with one roll of paper without producing any confusion in the record should an earthquake occur. Four record lines are written on this paper at one time. The top one of these records gives the vertical component of the motion; it is written by means of a glass siphon which is fixed to the lever, A_1 , with wax. The siphon draws ink

from the ink well, B_1 , and the motions of the lever are controlled by the mass, N , to the supporting lever of which it is connected by a fine wire or cord, C_1 and a cross bar, D_1 . The next two lines of record correspond to the two horizontal components of the motion. They are written by siphons fixed to the horizontal arm of the cranked levers, E_1 and F_1 , and draw ink from the ink wells, G_1 and H_1 respectively. The motions of these levers are controlled by the masses, A , to which they are connected by light connecting-rods hinged to the struts.

The lowest record line gives the time, and it is controlled by means of the clock, I_1 , which is arranged by means of a system of levers, illustrated diagrammatically in Fig. 3, to mark every five minutes and every hour on the paper, while the speed is about the normal amount, and to mark quarter seconds when the speed is increased at the time of an earthquake. The siphon lever is represented at J_1 , and is hung by two connecting-rods, K_1 , L_1 , the upper ends of which are respectively pivoted to two levers, M_1 , N_1 . The lever, M_1 , is pivoted at O_1 , and its point rests lightly against the edge of the wheel, P_1 , which is fixed on the end of the hour spindle of the clock. As the wheel turns round, the end of the lever (and consequently the point of the siphon) is raised every five minutes by the teeth on the edge of the wheel, and it is raised twice by means of a double tooth at the end of the hour. This records the five minutes and the hour intervals. At the time of an earthquake the ball, Q_1 , rolls forward on to the end of the lever, R_1 , and thus lowers the left-hand end of the lever, S_1 , and allows the point of the lever, N_1 , to touch the edge of the wheel, U_1 , which is fixed to the minutes spindle of the clock. At each beat of the clock the point of the lever, N_1 , is slightly raised by the slope of the teeth in the edge of the wheel, and this lowers the point of the siphon, thus recording quarter seconds on the paper.

The way in which the speed of the paper is changed is also illustrated in this diagram. At the beginning of the shock the ball, Q_1 , rolls from the rocking platform on the lever, V_1 , on to the end of the lever, R_1 , and thus at the same time raises the left-hand end of the lever, R_1 , and lowers the right-hand end of the lever, V_1 . As the end of the lever, R_1 , is raised the wheel, W_1 , is pushed out of gear with the pinion, X_1 , and allows the clockwork to run on without the governor, Y_1 . A second governor placed nearer to the driving power then governs the speed. The effect of lowering the right-hand end of the lever, U_1 , is to bring the wheel, Z_1 , into gear with the

pinion, A_2 , which is in gear with the driving clockwork. The wheel, Z_1 , is thus caused to revolve, and with it the cylinder, B_2 , which is cut with a slope on its top end. As B_2 turns round the right-hand end of U_1 is raised, and left-hand end lowered sufficiently to allow the ball to roll back on to the rocking platform. After this the right-hand end of the lever is allowed to fall, and the ball raised to its normal position. Just before the ball rises to this position the speed changes back to slow in consequence of the wheel, W_1 , coming again into gear with the pinion, X_1 . The apparatus is thus brought back to precisely the same condition as it was in before the earthquake, and will go through the same series of operations should another occur.

II.—ADJUSTMENT AND USE OF THE APPARATUS.

Foundation.—When set up for use this apparatus should be fixed with its sole-plate level on a substantial foundation. A stone pillar built up from the rock, if it is near the surface, or deep into the ground if rock cannot be conveniently reached, is the most suitable. The foundation pillar should not be high, and should be so rigid that its own free period of vibration is very short. In order to obtain sufficient length of fall for the driving weight, it is generally convenient to pass the driving cords over pulleys fixed to the foundation, and then again over pulleys fixed to the ceiling of the room in which the instrument is placed. A good arrangement is to place the weights at the side walls of the room, and lead the cord to them by means of pulleys. The pillar may thus be quite low, and in the latter arrangement the cord may pass across the room under the floor.

Paper.—The paper drums having been mounted in position as shown in the figures, the top screw of the drum, X , is made just tight enough to keep the paper stretched. A weight of about 10 lbs. should be kept on the cord which drives the train connected to the haul-off drum, Z , and (when driving on a double cord) about 28 lbs. on the driving train of wheelwork. The paper used should be as thin as possible, and should not be too smooth. Very thin printing paper suits well, and may be obtained cut to the breadth from the makers of the instrument.

Governors and Speed.—The governors can be adjusted so as to vary the speed very considerably. It is not advisable to reduce the slow speed below one-third of an inch per minute, because, if the speed be too slow, the time of occurrence of any disturbance

cannot be obtained with sufficient accuracy. The fast speed may be made as much as 3 feet per minute, but half of that will be found quite sufficient for most places. The speed should be sufficient to give good separation of the recorded waves. The speed is varied by raising or lowering the friction platforms on which the upper ball of the governor rubs. The governors consist of two balls on the ends of a cross arm pivoted to a spindle which is driven round by the clockwork. The cross arm is held nearly vertical, when there is no rotation, by a spiral spring, but tends to become horizontal when the spindle is driven round. When the speed reaches the desired amount, a plug of wood fixed to the higher of the two balls is made to rub against an adjustable horizontal plane.

Vertical Motion Pendulum.—The lever of this pendulum should be adjusted to the horizontal; first, approximately, by slackening the clamping screw and moving the weight along the lever, and finally, by turning the adjusting flag. The top of the connecting-rod of the compensating spiral springs should reach, when the spring is unstretched, a very little above the knife-edge marked Q in the figures. After adjusting them to this position they should be hooked on as shown. The point of the lever which remains steady during a sudden vertical movement of the earth is almost exactly the centre of the weight. The magnification is adjusted by changing the position where the connecting link is attached to the siphon lever.

Horizontal Motion Pendulum.—Care should be taken when adjusting these pendulums that the knife-edge rests fairly along its length against the bottom of the V-groove. This can be tested by feeling whether the strut can rock round a horizontal axis. The portion of the strut and the period of oscillation can be readily adjusted by means of the fitting at the top of the pillar described above. Lines and numbers are put on the outside of the strut which indicate the ratio of the motion of the steel cone on the end of the connecting-rod to the motion of the earth when the side of the weight nearest the knife edge is at the mark.

Siphons.—The siphons are made from thin glass tubing, obtained by drawing down from tubing similar to that used for thermometers. The thick walls and fine bore of this tube allow a tube of considerable strength, and yet of sufficiently fine bore to make a fine line, to be drawn. Siphons may be made by the user of the instrument by heating a piece of such tubing and quickly

drawing it down to the required thickness and then bending it, by the aid of a minute gas flame, into the proper shape. The writing point should be drawn down sharp and smoothed in the flame. To avoid trouble, the makers of the instrument are instructed to supply several sets of siphons, and, as these are made of such strength as to be little likely to break when moderate care is taken, they should be sufficient for a considerable length of time. New sets can also be obtained from them. The siphons should be fixed to the levers with wax and should just touch the paper sufficiently to insure a continuous flow of ink as the paper moves forward. Some difficulty was experienced with the earlier instruments, both with the siphons themselves and with the paper. The siphons were made very light, and consequently very fragile, and most experimenters found difficulty in fixing them without breaking them. The paper again was of a very thin and cheap description, and was found to be irregular in quality, some parts being so spongy that the ink flowed too freely at the slow speeds and produced a blurred line. These difficulties have, however, been largely got over by having better paper supplied specially on a large scale to the makers of the instrument, from whom it can be readily obtained.

Ink.—The most convenient ink to use is a solution of aniline. This need not be strong, and it is convenient to keep a stock bottle made up to a strength which would make a good ordinary writing fluid. Care has to be taken that the siphons dip well into the ink, but that they do not touch the bottom of the box at any part of the range of motion.

Change-Speed Mechanism.—In the use of this apparatus, two things have to be attended to. One of these is the time at which the speed changes back to slow, relatively to the time the wheel, Z_1 , comes out of gear with the pinion, A_2 , Fig 3. This can be varied by screwing up or down the stop-screw, C_2 , Fig. 2, which should be screwed down far enough to allow the speed to change back to slow, a little before the wheel, Z_1 , stops turning. The other thing to be attended to is the position of the screw, D_2 , which regulates the delicacy of the starter; it should be screwed forward until the ball just rests stably.

III.—THE INTERPRETATION AND USE OF THE RECORDS.

In earthquake investigation there are a great variety of physical phenomena to which attention may be directed. That to which,

material the greatest amount of attention has been given is the determination from some physical characteristic of the shock, of the origin of the disturbance. This is no doubt a very desirable thing to find out, it is well to bear in mind that the evidence furnished by the shock itself as for this purpose, apt to be very misleading. The very common mode of attacking the problem is to determine the direction of the motion at different points of the earth's surface and hence the often-quoted east and west, or north and south, and direction of an earthquake. There is nothing more common, however, than to find different observers, residing in or near the same place, giving most discordant accounts of the movement of the shock. This is very significant, but probably depends in many cases, on a variety of local circumstances, and on errors of judgment on the part of certain, or possibly all the observers. When no instrumental means are available the conclusion is apt to be reached that no one can be depended on in such matters. If however, we apply to an inanimate machine for a solution we are generally met by precisely the same difficulty. The different machines, although only a few hundred yards apart, will not infrequently give quite discordant indications, and, generally speaking, no two sets of machines, giving simply the direction of motion, will indicate the same position for the origin, considered either with regard to surface position or depth of focus. This leads us to consider whether our fundamental assumption, according to which we expect the directions of motion at different places to have a common point of intersection, is likely to be correct. As the motions constituting an earthquake shock are of the nature of wave motions, either regular or irregular, according to the nature of the medium through which it is transmitted, we may profitably consider what we are likely to gather from such motions propagated from a centre. In the first place, no matter how uniform the material may be through which the waves of disturbance are propagated, we are almost sure to have at least two kinds of waves, one or both of which exist at the same time. In one of these sets of waves the motion is transverse to the direction of propagation, and the velocity of transmission depends on the density of the material and on the resistance which it offers to distortion. In the other the motion is in the direction of propagation, and it is transmitted at a rate depending on the density of the material and on the resistance which it offers to a combined compression and distortion of the peculiar kind necessary to the

existence of such a wave. The difference in the velocity of transmission for these two kinds of waves is considerable, and is important when both exist, because it is easy to infer which is the direct and which the transverse wave, the direct wave being transmitted with the greater velocity. If the probability of the existence of these two kinds of waves were all that had to be considered, it might still be possible to make out something from the direction of the motion at different points, but, unfortunately, the problem is much complicated by the want of uniformity of structure in the rocky strata. This gives rise to different rates of propagation in different directions, and to refractions and reflections of the waves, which are a great cause of the diversity in the deductions derived from the direction of motion at different points.

Nearly all the calculations which are based on observations of this kind, as to depth of centrum, size of focal cavity, position of centrum and epicentrum, and so on, are of little value. The same is the case with the deductions drawn from cracks in buildings, tilting over and twisting round of columns, the indications of seismometers, &c. Deductions as to depth of centrum, derived from the "angle of emergence" of the wave, are particularly apt to be misleading on account of the great variation of the nature of the strata downwards causing a large amount of refraction, and on account of the effect of the free surface, which tends to make the apparent angle of emergence much greater than the real one. Again, consider the effect of a transverse vibration. Clearly this might be either horizontal or vertical, and hence might give rise to the idea that the motion was purely vertical or purely horizontal, or it might give rise to all possible angles of emergence. As has been already pointed out, there is an important difference between the two kinds of waves, namely, that they are transmitted with different velocities. It is therefore interesting to find whether both waves have reached any given point, and this is one thing that accurate instrumental record of the motion is good for. The interval between the transit of the two waves gives an idea of the distance of the origin. Again, the amount of the disturbance at different places is of great importance, because when proper precautions are taken in the interpretation of the records the circles of equal disturbance will approximately have the origin in their centre. It need hardly be pointed out that observations at a few points are generally sufficient to determine

the circle. In this case instrumental records are essential to the acquisition of relative information. Another point is that as we recede from the centre of disturbance we will, on the assumption that we are observing the direct wave, have a gradually diminishing vertical component and a gradually increasing horizontal one for some time, but after a certain distance is passed the horizontal component will also diminish. The circle of maximum horizontal intensity is important as its radius will be approximately the depth of the focus. So far, then, as the components of the motion are concerned the points of most importance for the determination of the focus are their relative amplitudes among themselves at the same place, and the relative amplitude of the resultant motion for different places.

We want, however, to know the character of the motion for other purposes than mere origin-hunting, because we have an interest in knowing what kind of structures are likely to withstand the shocks which visit various localities, and we want, as a piece of physical information, to know the changes which the waves undergo as they are transmitted forward through the various strata. The rate of absorption of the wave as it is transmitted along any one stratum, and the changes that the waves undergo as they pass from one stratum to another, are also interesting. Combining geological knowledge of stratification with seismographic investigation offers an inviting field for experiments in elasticity on a large scale.

So far I have only considered the magnitude and the direction of the motion. There is, however, a time element which is much more important for the determination of the origin. Suppose, for example, that several stations are carefully chosen so as to have continuous rock formation of nearly the same structure between the different instruments: then the time of arrival of the disturbance at the different instruments gives information of great value for the determination of the centre of the disturbance. Assuming that the origin is at a small depth below the surface, compared with the distance of the instruments, three stations are sufficient to determine the position of the focus: this implies the addition of time-registering appliances to the apparatus, and hence the clock in the seismograph.

There is another time element of very great importance, namely, the rapidity of the vibration. It is clearly this that causes small earthquakes to do damage, when the damage is not attributable to

secondary causes, such as swinging of the building, due to long-continued tremors of a suitable period. Generally speaking, very small tremors have a very quick vibration, while motions of considerable magnitude are slow. The rate of acceleration of a mass on the earth's surface is the important element, as this determines the force acting on it. Hence, for engineering purposes we want not only the magnitude of the oscillation but the period of it, and this is the main reason why the speed of the paper-feed is increased at the time of the earthquake.

XXVII.—A Demonstration in Bacteriology, illustrative of the mode of Growth and Cultivation of Micro-organisms found in Air, Food, and Water, embracing also some of those which grow on the Skin. By A. ERNEST MAYLARD, B.S., M.B. LOND., Surgeon to the Out-patient Department of the Glasgow Hospital for Sick Children; Extra-Dispensary Surgeon to the Western Infirmary, Glasgow.

[Given by special request of the Society, 25th March, 1888.]

MY object this evening is to give you a practical demonstration upon the subject of MICRO-ORGANISMS, or "germs," as they are perhaps more popularly known: to show you these minute organisms isolated and growing upon certain nutrient media; and to illustrate the means adopted for acquiring and cultivating them. While many, indeed most of my hearers will be, to a certain extent familiar with the nature of these organisms, there are those probably who would be glad of some brief preliminary explanation. I must ask, therefore, the better-acquainted of my audience to kindly bear with me, while I preface my demonstration with a few short remarks upon what has now become to be designated and known as the science of Bacteriology.

The minute organisms embraced by this science are from their excessive smallness termed micro-organisms. The term bacteria is also frequently applied to them. So low are they in the scale of organic life, that until recent years, they had been considered as occupying the boundary line between the animal and vegetable kingdoms, being deemed as much of the nature of animalcules as of plantlets. They are now, however, generally accepted as belonging exclusively to the vegetable kingdom. When seen under the higher powers of the microscope, they appear generally in the form of round or rod-shaped cells—the round form being called micrococci, and the rod-shaped bacilli.

Their minuteness may be judged from the fact that the diameter of the round cells or the transverse section of the cylindrical cells

is in most cases not above the one-thousandth of a millimetre ($\frac{1}{25000}$ inch). The micrococci have no movement beyond that which is seen in all particles of matter; but many of the bacilli appear to have a definite progressive motion.

Bacteria multiply by fission and the formation of spores. In the former process each organism divides, and the parts so separated develop into adult bacteria; in the latter, a small round or oval-shaped body forms in the adult organism, and when ripe is ejected from the mother cell and grows into the adult. So rapid is their rate of development that, under conditions of suitable soil and temperature, they will, in the course of a very short time, augment their number a million-fold. Unfortunately, perhaps, for us their tenacity of life is very great, so great, indeed, that many of them will resist temperatures and other conditions totally destructive of higher organic life; and herein lies, it may be incidentally remarked, the sole secret of all our present practical difficulties in the treatment of such diseases as are known to be due to them. How are we to destroy the parasite without deleteriously affecting the host? We have arrived by experiment so far as to know how to kill the bacterium when isolated, but as yet we know of no means how to do so when the *nidus* of the germ happens to be the human system.

Although, as I have said, the higher powers of the microscope are needed to see these organisms individually, they can, with equal certainty, be detected by the naked eye when occurring collectively. It is in this condition that I am dealing with them this evening. So conglomerated they constitute what are termed "colonies," and as not a few produce highly-coloured pigments, it becomes an easy matter to study them under various phases of development.

While it is now many years since the existence of these minute organisms was first discovered, it is only within comparatively recent times that a relationship has been shown to exist between them and certain diseases. This association, discovered by Pasteur, Koch, Lister, and others, has infused into the subject an importance out of all proportion to what it would otherwise have had; and so universal has become its significance that it behoves not only the medical man and the scientist in general to study it, but demands the careful attention of every individual if his own health and that of the community at large are to be maintained.

With these few cursory remarks upon the life-history of bacteria, I may now pass on to the practical side of my subject; and, first

it all of the slow but sure of the means we adopt and the result we obtain in the improvement and cultivation of micro-organisms.

STERILISING MEANS

The first primary condition in our investigations is to have all material we use absolutely sterile. This is to say, every possible micro-organism or spore which in any way must be counteracted, or in other words any bacteria present must be killed. To accomplish this we have at our disposal three adequate means:—washing with a strong solution of bichloride of mercury; dry heat up to and above a temperature of 150° C. (302° F.); and steam. By one or other of these means we are able to ensure our utensils and materials remain being perfectly fit for use.

The strength of the mercury solution used is generally about one part of the mercuric bichloride to two thousand parts of water. As a sterilising agent it is used for cleaning glass dishes, such as a high temperature would be likely to injure; for washing the operator's hands; and disinfecting such media as have already been used and which it is desirable to render sterile before disposing of them.

The dry steriliser consists of a metal box heated beneath by Bunsen burners and containing in its roof a thermometer for registering the temperature. Into this are placed all glass receptacles that can be safely raised to a high temperature; also cotton wool, glass rods, pipettes, knives, &c. The glass test tubes, which are so largely used for cultivation purposes, are stopped with cotton wool and then placed in this chamber, where they are heated on two or three consecutive days up to a temperature of 150° C. for three-quarters of an hour.

The steam steriliser consists of a long metal cylinder heated below by Bunsen burners and containing, like the dry steriliser, a thermometer in the lid for registering purposes. The lower part of this hollow cylinder contains water, and a few inches above the surface of the water a perforated diaphragm. This latter, while it allows the steam to freely pass through, serves as a support for whatever may be placed upon it. The steam steriliser is used mostly for sterilising the various cultivating media which are placed within it, when the thermometer in the lid registers 100° C. (212° F.)

CULTIVATING MATERIALS.

The media which we use for cultivating bacteria are of many kinds, but I shall not trouble you with more than two or three, and those such as I have before me. It must be remembered that, while, as I have already stated, these minute organisms are extremely tenacious of life, and will live under conditions totally unfit for, and incapable of, sustaining the vital existence of more highly organised beings, they are nevertheless peculiarly fastidious over the soil they require for growth and multiplication. Temperature also plays a not unimportant part in influencing development. Thus we find some organisms incapable of increasing their number, except when at the temperature of the human blood, while others will thrive at the ordinary room temperature. Again, some will multiply only when freely exposed to the air, while others need no such exposure for their development. In catering, then, for the requirements of bacteria, we have to carefully select those media and external conditions which are likely to prove most suitable for the propagation of any particular species. In many cases this has to be done empirically, but in not a few a clue to the proper composition of the artificial media is derived from the constitution of the natural habitat.

I have here before me three different cultivating media. This clear, transparent substance, resembling very much calf's-foot jelly, is called Koch's beef peptone jelly, and is one of the most serviceable media we possess. It is composed of gelatine, peptone, meat extract, and salt, in certain proportions—the mixture being rendered neutral or slightly alkaline by the addition of a saturated solution of bicarbonate of soda. Although seen here as a solid, it readily liquefies at a temperature of about 22° C. (72° F.). As solidity is an essential requisite in many of our investigations, it becomes unsuitable for the cultivation of such organisms as require the temperature of the human blood for their development, which is 37° C. (98·6° F.) For these, therefore, we have to make use of another substance. This which I show you here in the form also of a jelly is less transparent but much more solid than that just mentioned. Like Koch's preparation, it contains meat extract, peptone, salt, but in the place of gelatine, Agar Agar—an extract obtained from sea-weeds growing on the coasts of India and Japan. To liquefy this jelly a temperature approximating boiling point is needed.

The third medium consists of steamed potatoes, which, when sufficiently cooked are sliced, and the surface so exposed constitutes our cultivating soil.

In this staggered test tube is some of Koch's beef peptone jelly. It has been allowed to solidify, while the tube has been kept inclined so as to give a more extensive surface for planting purposes. It is now six weeks since this was prepared, and it is still perfectly good and fit for use. Here is a tube in which a bacterium is growing upon the oblique surface of the jelly. (Plate IX., Fig. 6.) It looks not unlike a smudge of white paint, but in reality it represents the growth of the micro-organism. When first implanted it was a faint, almost imperceptible streak, and now, from gradual extension through multiplication of the bacteria, it has assumed the appearance you see.

NATURAL HABITAT OF BACTERIA.

A word now about the bacteria themselves. Whence are they derived? or, in other words, where are they found, and by what means are they isolated? It would almost be easier to say where they do not exist, rather than to state where they do, so all-pervading are they in air, earth, and water. It does not seem pleasant to contemplate, that in this great city in which we dwell the very air we breathe teems with them; the water we drink swarms with them; and the soil we tread upon is crowded with them. Yet so it is; and it is part of my object this evening to practically demonstrate these facts to you, and to illustrate the various conditions which tend either to lessen or increase their numbers in each of the media already mentioned.

BACTERIA IN AIR.

Let us first take air. I show you here what is termed "a plate cultivation." It consists of a thin plate of glass, six inches by four, covered with a thin layer of Koch's beef peptone jelly. The glass plate, previously sterilised, was placed upon a large glass slab, itself resting upon a glass dish containing ice and water, and levelled by a tripod. A test tube containing Koch's beef peptone jelly was slightly heated in order to liquefy the medium. This was then poured upon the glass plate, and spread out as a thin layer upon its surface. The ice beneath the plate soon caused the jelly to congeal. The plate thus prepared was then placed with its jelly surface upward at some place in the laboratory, and left

exposed to the atmosphere for half-an-hour. The excessive minuteness and lightness of bacteria admit of their being carried about by the slightest breath of air. Their tendency is always to gravitate to the ground; and so it comes about that both by means of downward currents and their own weight several are brought in contact with the surface of the jelly. Here they stick, and finding, as most or many do, a suitable soil for development, sooner or later show signs of growth. This plate, after half-an-hour's exposure, was placed in a glass chamber, where any further contamination of the jelly was precluded, and you now see the result at the end of seven days. (See Plate IX., Fig. 1, which, although representing a plate differently treated and to be described later, sufficiently indicates the points here depicted.) There are twenty-seven colonies, indicating approximately the number of individual micro-organisms originally deposited. These colonies, you will observe, present many differences as regards their size, colour, and effect upon the jelly. They are mostly circular, but some are much larger than others. In colour some are white, some pink, some yellow, and some greenish. In their effect upon the jelly, some appear to grow only on the surface, some grow deeply in its substance, and some liquefy the substratum, producing a turbid fluid. These various differences are characteristics in the life-history of each organism.

Here is a second plate (Plate IX., Fig. 2), which has been exposed in the open air for an hour, and the colonies seen are the result of seven days' growth. There are in all no fewer than ninety separate colonies.

I have here a third plate which has been somewhat differently treated. The plate was exposed for two or three minutes in a room while being swept. The room itself had for a long time been unoccupied, and for weeks had never been entered. The sweeping, therefore, raised much dust, and as dust is one of the best carriers of these minute organisms, the surface of the jelly soon became copiously sprinkled with particles. The plate, like the preceding ones, was put aside for a week, and here you see the result. It is simply crowded with colonies. In a similar experiment tried some time back, no fewer than three hundred and sixty-two colonies developed. About two weeks after the latter experiment I placed another plate in the same room. The room in this interval had been kept closed, so that everything in the interior had been in a perfectly quiescent condition. The

room was slowly and cautiously entered, and the plate deposited at the same place as the previous one had been. It was left exposed for half-an-hour, and then put aside for a week. At the end of that time only nine colonies had developed, and it is more than probable that these were the consequence of the slight disturbance unavoidably caused in the atmosphere through entering the room.

Unless, therefore, under the exceptional conditions just indicated, in the higher region of the atmosphere, and at parts of the sea far distant from the land, the air may be said to literally swarm with life. It would seem from experiments which have been made on much the same lines as those which I have just demonstrated—modified somewhat for quantitative rather than qualitative analysis,—that the number of micro-organisms found in any given volume of air is in direct proportion to the density of the animal population, and still further to particular conditions affecting that population; or, to put it in plainer terms, the largest number of micro-organisms will be found in the atmosphere of crowded communities, occupying ill-ventilated and uncleanly spaces. It is under these conditions that dead organic matter is frequently found in greatest abundance, and no soil seems so suitable for the rapid and prolific propagation of bacteria as that of lifeless vegetable or animal matter.

So far as the air itself is concerned, it must be remembered that it is simply the carrier of these minute organisms, and it is only when they are by this means brought in contact with organic matter that they multiply and bring about those innumerable fermentative changes with which our noses too frequently acquaint us. I need only mention such familiar domestic experiences as are observed when meat becomes what we call "high;" fish, putrid; milk, sour; or light alcoholic wines, acid; fruit, rotten; and so on, to bring home to you the active influence of these organisms.

But let me pass to some other practical observations in connection with the bacteria of air. It is part of the duty of the bacteriologist to study in every possible way the life-history of these organisms, just as the botanist or horticulturist watches the growth of a plant, or the naturalist studies the habits and characters of any particular animal. With this object in view, then, we proceed, after having obtained our microbe, to make what is termed a pure cultivation of it. To do this, I take what

is termed a platinum needle, which consists of a glass rod, having fixed into one extremity a piece of straight platinum wire. This is first sterilised by heating it in the flame of a Bunsen burner, and, when cooled, is made to touch lightly one of the colonies on the original plate cultivation. Some of the bacteria will adhere to the point of the needle, and when so secured can be transferred to the surface of another cultivating medium upon which it is desired to obtain a growth. I will now show you several such pure cultivations, obtained in the manner just described. This beautifully pigmented growth (Plate IX., Fig. 3), is called the *Micrococcus prodigiosus*. You see it as a brilliant red streak on the surface of the Agar Agar. Here it is again growing in Koch's jelly (Plate IX., Fig. 4), liquefying the medium in its process of development, and leaving the medium so liquefied tinted with the beautiful pigment which constitutes its specialty. It is seen also growing luxuriantly on this potato (Plate IX., Fig. 2), producing in like manner its characteristic colour. In this tube is seen a yellow micrococcus (Plate IX., Fig. 8), growing on Agar Agar; and here again it is seen growing on the surface of a potato. This is a pink torula (Plate IX., Fig. 7), growing on the surface of Koch's jelly; seen here also growing on the surface of a potato. This again is a white micrococcus (Plate IX., Fig. 6), one which I have already drawn your attention to. Here is still another, an orange-coloured micrococcus, growing on Agar Agar. These are just a few among many which I might show illustrative of pure cultivations of bacteria found in air.

Besides studying simply the growth of these organisms: noticing what soil suits them best: under what temperature they thrive and multiply most prolifically: in what way they grow in or on the substratum: and many other such points; there is still further a very important consideration in their life-history which I cannot do more than barely allude to, but the possible future importance of which demands that I should not entirely pass over. The point has reference to the bodies formed by the growth of any micro-organism. In the multiplication of its species the bacterium assimilates to itself such ingredients as are necessary for its development. These are derived mostly from—sometimes in the case of those called anærobic (not needers of air) entirely from—the cultivating medium. As the result of this process of abstraction, certain bodies are left behind of a totally different character from anything which previously existed. In the growth of the

Saccharomyces cerevisiae or common yeast plant we have a familiar example. The result of the development of this organism is the formation of alcohol and the liberation of carbonic acid gas. We are familiar enough also with those offensive products popularly known as the gases of decomposition. These are produced by the growth of bacteria upon dead organic matter. To illustrate practically the changes which I am describing, I show you here a tube containing the bacillus of green pus (Plate IX., Fig. 5). You will observe that the lower part of the tube contains unaltered jelly, while the upper part consists of a green pigmented fluid material. Now, at the junction of the two parts there is a white septum dividing them, and this white septum is composed entirely of bacilli. This tube originally contained nothing but pure solid jelly. It was inoculated by means of a platinum needle which had adherent to it a few bacilli obtained from another tube. The result has been that as the bacilli multiplied they fed upon the jelly and left behind the pigmented fluid upper layer which in every respect is wholly different from the original substance.

The *Micrococcus prodigiosus* growing in Koch's jelly (Plate IX., Fig. 4), to which I have already drawn your attention, is another illustration of the same character. Here the jelly is similarly liquefied, but the pigment is red instead of green. The interest of this subject centres upon the question whether or not many diseases may be due to these secondary products, *Leucomaines* or *Plomaines*, as they are technically termed, rather than directly to the bacteria themselves. I must not, however, pursue this matter further. It is a subject as yet in its infancy, but growing out of the study of Bacteriology, and with probably a great future.

BACTERIA IN EARTH.

I now turn to the examination of earth. That earth should be a fruitful source of bacteria goes almost without saying. The constant deposition of vegetable matter, as well as that derived from animals, renders it a particularly fertile soil.

To examine earth a few grains of mould are taken and dropped into a tube of Koch's jelly which has been previously melted. The jelly is carefully shaken to diffuse as much as possible the grains throughout the medium. It is then at once poured upon a glass plate, and caused by means of ice to rapidly solidify in the manner I have already described to you. The minute particles of mould thus become fixed, and the micro-organisms separated from,

or attached to them, will, in the course of a few days, develop into visible colonies. Here is a plate prepared in the way described. The mould was taken from a garden a few days ago, and the plate has been kept protected from atmospheric contamination since. The result as seen shows an innumerable collection of colonies, varying in the many respects I have already shown you in the case of air.

BACTERIA IN WATER.

The subject of the investigation of water, to which I next ask your attention, is one of considerable interest. By an examination of this kind we are able approximately to determine the comparative purity of any sample. This particular method—the bacteriological investigation of water—has not yet found its way in this country into the usual practice adopted for such examinations. The periodical reports issued by public analysts are based almost solely on chemical analysis. That this mode of examination, however, will sooner or later find its way into being adopted as a regular routine practice there is little doubt. It will add information of importance, as well as more forcibly confirm conclusions which at present are derived from purely chemical analysis.

From the number of micro-organisms which we have already seen exist in the air, it is quite natural that many of these should find their way into this medium, wherever it may be exposed. Besides this inevitable and very fertile source of contamination, however, there are bacteria peculiar to water itself, and these of many kinds. Water in one respect much resembles air, in that it is a means of conveyance of bacteria. Unfortunately, most of these minute organisms seem to be totally unaffected by immersion, and while finding in pure water no food fit for their development, they need but to reach a suitable soil to prolifically propagate their species. Thus, even what we term pure water, may under such circumstances contain the most noxious impurities.

I will now describe the practical method for making a bacteriological investigation of water.

If the same method be adopted as has just been demonstrated in the case of earth, that is to say, the mixing of a small quantity of water with nutrient jelly, we have an opportunity of ascertaining the existence of bacteria from the development of colonies which subsequently takes place. The actual practical method, however, of carrying out this examination differs somewhat from that just

described. The danger which has to be met and overcome consists in the possibility of any contamination taking place from the air. In all cases where the open-plate method of cultivation is adopted this is an ever-present risk, and one very difficult, if not almost impossible, to prevent. The difficulty is, however, surmounted by proceeding as follows:—

A properly sterilised stoppered test tube is taken, and into it is placed a small quantity of Koch's jelly. This is then sterilised again in the steam steriliser, and kept for a week or two in order to test its absolute purity. In proceeding to make use of it, a measured quantity—which rarely exceeds half a cubic centimetre (about four drops)—of the water to be examined, is inserted into the previously liquefied jelly. It is gently shaken to ensure that the water is well dispersed through the medium. The tube is now held almost horizontally and rotated rapidly in its long axis beneath a constant stream of cold water. The gradual process of cooling induced by the cold water causes the jelly to congeal and adhere to the sides of the tube until it finally solidifies as a thin film lining the inner surface of the tube. Any micro-organisms, therefore, which may have previously existed in the water will now become fixed in the solid jelly. The tube so prepared is laid aside and watched from day to day. If the water inserted contained organisms, those capable of development in this medium and under the conditions employed would sooner or later form visible colonies; and these, from the transparency of the soil in or upon which they are growing, would be easily detected.

By this method we can approximately ascertain the quality and quantity of bacteria contained in a given measure of water. As in the case of air, if we wish to examine more fully the micro-organisms thus found, we proceed to make pure cultivations by inoculating other cultivating media from these separate colonies.

I now propose to show you the results of several examinations made in the way just described; and, first, I will take Loch Katrine water, such as it is, as it flows from the tap in my laboratory.

In this tube (Plate X., Fig. 1), was placed half a cubic centimetre of water—that is to say, about four drops. It was inserted four days ago. Two colonies have so far made their appearance, which may be taken as representing $\cdot 5$ bacteria per drop; or, if we take the drop to represent a minim of our ordinary measure, we have 4,800 to the pint.

As the result of a few tests made this winter, I have found considerable variation in the number of organisms present in a given quantity of this water. The average may be given at 1 or 1.5 per drop. On one occasion no development was observed; on another as many as 4 per drop. Notwithstanding the apparently appalling number constituting the average, that is to say, some 9,600 per pint, this, considering the natural ways through air and earth by which contamination is necessarily brought about, may be taken as indicating particularly pure water. In striking contrast to this investigation, and to relieve your minds of any unpleasant feeling associated with the imbibition of about 5,000 microbes in an ordinary tumbler of water—for in truth the number is a mere fraction—I will give the result of an investigation of Clyde water. The water was taken from mid-stream about opposite Govan Pier. The usual quantity of half a cubic centimetre was inserted, and on the third day such a development had taken place as to be totally beyond the power of human calculation. The jelly, too, had putrefied to such an extent as to be quite offensive on removal of the wool stopper. Finding this quantity of water far too much to enable me to arrive at any calculation of the possible number present, I next tried a single drop only, with the result that about 1,500 colonies developed—thus bringing the number per pint up to the almost inconceivable quantity of 14,400,000. I here show you a tube which had placed in it three days ago a single drop of Clyde water, taken from the same place as that originally investigated, and you will see how extensively speckled is the thin layer of jelly lining the inner surface of the tube.

In view of the interest which has recently been awakened by the report of the Government Inspector upon the pollution of Lochs Long and Goil—a report based apparently solely on a chemical analysis,—I thought it might prove interesting, and possibly instructive, to make a bacteriological examination of these waters. For this purpose I visited the Lochs on March 3rd, accompanied by my friend and colleague, Dr. Joseph Coats. Samples of water were taken from three different places: one from Loch Goil, close to the pier at Carrick Castle; a second from mid-stream, at the entrance of Loch Goil; and a third at the entrance of Loch Long, midway between Cove and Blairmore. In each case half a cubic centimetre was examined. In that obtained from opposite Carrick Castle, ten colonies developed;

in that from the entrance of Loch Goil, only four; and in that from the entrance of Loch Long, no fewer than about 500. Too much must not be drawn from this single investigation, and made, too, in the winter; but such as it is, it points to a purity of Loch Goil equal almost to that of Loch Katrine, as examined from the tap in my laboratory; and of Loch Long—at the part examined—to a condition little better than parts of the Clyde itself. Whether Loch Goil would show the same degree of purity in summer, when there is little water entering the head of the Loch, is very doubtful. A proper examination made in the summer might prove of much value. Much was made in the Inspector's report of a slimy scum noticed upon the surface of still water at the head of some of the Lochs. This was ascribed to sewage matter; but the description suggests the possibility of its being some of those organisms familiar enough to the bacteriologist, known as *Crenothrix*, *Cladothrix*, *Beggiatoa*, and others frequently found floating upon the surface of still waters.

To better compare the relative purity of the waters, the examinations of which I have just given, I will draw your attention to the following table where the number of organisms are given per litre:—

Loch Katrine, ...	...	...	...	...	...	17,280
(by laboratory tap.)						
Loch Goil, ...	...	...	...	...	...	21,600
(close to Carrick Castle pier.)						
Loch Goil, ...	...	...	...	...	...	8,640
(at entrance, mid-stream.)						
Loch Long, ...	...	...	...	...	...	2,160,000
(at entrance, mid-stream.)						
River Clyde, ...	...	...	...	...	...	25,920,000
(opposite Govan pier, mid-stream.)						
River Clyde, ...	...	...	...	...	...	870,912,000
(same water after standing for 24 hours.)						

You will observe the enormous increase which has taken place in the number of micro-organisms present in the Clyde water when it is allowed to lie stagnant for a short time. This increase can only take place as the result of a suitable soil for the development of bacteria, and indicates the large quantity of organic matter which the water must hold in suspension. I have made similar examinations of Loch Katrine water, allowing it to stand for a time and then comparing the development with the number of colonies originally observed. The increase was extremely slight.

Before leaving this part of my subject I show you here some pure cultivations of bacteria taken from colonies which had development as the result of the examination of Loch Katrine water. They belong to the class bacilli. In this tube you see a whitish streak coursing along the surface of the nutrient medium. The jelly itself has become tinged a beautiful bluish-green colour, and for this reason the organism is designated the green bacillus of water. In this tube is a very similar bacillus; it is growing on Agar Agar, which, like the other, assumes a beautiful greenish tinge. If, however, this bacillus be planted upon Koch's jelly it rapidly liquefies it. On these two potatoes are two other kinds of bacilli met with in water, the one from its characteristic colour called the violet bacillus, and the other, for a similar reason, the red bacillus of water.

As to the import to be attached to the presence of bacteria in water, it may be taken as an approximate truth that the existence of bacteria involves the co-existence of organic matter, and that the number of the former is pretty much in direct proportion to the quantity of the latter—the more bacteria the more organic matter.

The methods which I have briefly described in the bacteriological examination of air, earth, and water, are such as, in principle, are followed in the investigation of all other matter, whether solid or fluid. By thus treating blood, secretions, excretions, tissues of diseased parts or organs, we are enabled to detect the existence of, and to isolate for further examination, the various micro-organisms associated with special diseases. In this way has Koch established the specificity of the tubercle bacillus; Fehleisen the micrococcus of erysipelas, and others; and it is thus we may hope yet to make new discoveries.

Before concluding, I should say that I have in front of me a few cultivations of some of the bacteria which produce special diseases. They are technically termed pathogenic organisms. This is the anthrax bacillus, the bacillus of splenic fever in cattle, wool-sorter's disease, or malignant pustule, growing on the surface of Agar Agar, and potatoes; it develops very rapidly, producing a greyish-white layer. Its growth in Koch's jelly is much more characteristic. When the needle is plunged into the substance of the jelly, a faint line indicating its track is all that is seen at first; but in the course of a day or two very delicate needle-like processes shoot out into the jelly at right angles to the line of the needle puncture. Subsequently, as the bacillus develops, it

completely liquefies the jelly. Here is a second tube containing one of the commonest organisms found in pus. It is called from the peculiar grouping of its cocci, from its origin, and from the colour of the pigment it produces, *Staphylococcus pyogenes aureus*. You see it as a yellow streak on the surface of Agar Agar; and here again on potatoes, as a well-marked golden yellow patch. In this tube is Koch's "comma" bacillus, or the bacillus of Asiatic cholera growing in a manner quite peculiar to itself. This, again, is Frædländer's pneumococcus, the organism which he has described as the cause of pneumonia; and this is the bacillus of typhoid fever.

It would carry me far beyond the limits of the time at my disposal to do more than simply show you these cultivations which produce disease; but to convey to your minds, with some sense of conviction, the actual potency of some of these pathogenic microbes when introduced into the animal system, I will give one example.

From a pure cultivation of the anthrax bacillus, such, for instance, as I have shown you on Agar Agar, Koch's jelly, or potato, a mouse was subcutaneously inoculated, that is to say, some of the bacilli were removed from the surface of the cultivating medium by means of a platinum needle, and inserted beneath the skin. The mouse began rapidly to sicken, and within from twenty-four to forty-eight hours died. The internal organs were then removed and placed in spirit. When sufficiently hardened, sections were cut and obtained for microscopical examination, and it was then found that the various vascular channels were crowded with bacilli of the same kind as those inoculated. We have, then, this fact, that within the comparatively short time of thirty-six hours, the bacilli have circulated through the system and multiplied to such an extent as to be found densely packed in the blood channels of every organ of the body. This drawing (Plate X., Fig. 2), taken from the section which you will see here under the microscope, accurately represents the condition. The section was taken from the liver. The part stained pink represents the liver substance; the open spaces, the blood channels; and the blue rod-shaped bodies, the bacilli. They are, you observe, scattered throughout the whole section, but in one or two places they exist massed together like solid plugs.

With such conclusive evidence as this, no doubt can possibly be left in the mind of any one that the cause of the disease and

the cause of death were in some way intimately associated with the bacilli inoculated. I might give examples equally convincing of other kinds of organisms, and especially from my own domain of surgery, where, it is not too much to say, a large proportion of the cases we, as surgeons, are called upon to treat, are due in one way or another to microbes. The one I have given, however, is, I hope, amply sufficient to establish the sequence of cause and effect between bacteria and certain diseases.

While it has not been my intention this evening to do more than demonstrate facts, I feel I can hardly leave my subject without at least suggesting the train of thought which these facts should give rise to, and the possible inferences that might be drawn. Although it has been shown that air, earth, and water alike swarm with microbes, it must not be concluded—as it often erroneously is—that all the various organisms are necessarily of a nature injurious to higher organic life—to man or beast. Indeed, the majority have been proved by experiment to be perfectly harmless, and some even to be of actual good. A tumbler of turbid water, with its millions of innocuous microbes, might be relatively as nutritious as a basin of soup. In each case it is purely a matter of cells. In the one they are single and of supreme smallness, in the other, large and united in complex combinations. We might divide the world of life into the macroscopical and the microscopical: the one seen by the naked eye, the other by the aid of the microscope; and just as there are known to all to be constituents of both the animal and vegetable kingdom, which, in the more obvious world, are injurious to human life; precisely so also are there constituents of both kingdoms in the less obvious or microscopical world similarly injurious to our existence. A cultivated field, or better, an uncultivated one, will contain numerous species of plants, the majority of which would prove, as food, quite harmless; but there might exist a few productive, when eaten, of dangerous and even fatal results. Just so is it with these myriads of minute organisms which the bacteriologist discovers by methods of cultivation and the microscope, in air, earth, and water. But in the analogy between these two worlds—as I have ventured to describe them—there are still further important factors, and wherein lie, perhaps, the most cogent and instructive teaching of the subject before us. They are two: one the growing together of the harmful and the harmless; and the other that the same

soil is equally suitable for both. With regard to the microscopical world, I have shown you both innocent and injurious bacteria growing on the same kind of cultivating material: the *Micrococcus prodigiosus*, for instance—a bacterium of the air, and incapable, so far as we know, of producing any kind of disease—growing luxuriantly upon Agar Agar, Koch's jelly, and potato; and the anthrax bacillus—one of the most fatal—growing prolifically upon precisely the same media.

Thus, then, with these minute organisms, as with all others higher in the scale of life, one primary essential for active development is a suitable soil, and that soil may be as conducive to the welfare of the most innocent as to that of the most harmful. As I have already indicated, the existence of a large number of bacteria means the co-existence of a proportionately large quantity of organic matter; and, as in the uncultivated field, there will almost certainly spring up amidst the many innocent weeds a few that would possess poisonous properties, so are there only too likely to be found in an abundant organic bacterial soil some microbes at least capable of causing disease. So long, therefore, as we have a soil capable of supplying the necessary nourishment for bacterial development—and in proportion also to the amount of that soil—are we harbouring conditions conducive to the lighting up, maintenance, and extension of disease.

If, as a bacteriologist, I was asked to express in as simple and practical terms as possible the conditions which, in domestic hygiene, would lead me to believe as the most suitable for the growth and propagation of bacteria, I would say ill-ventilated, overheated, crowded, filthy apartments. If your worthy President was asked where he would expect disease most likely to arise and spread, he would, I think, give the same answer as I have given.

Bacteria and certain diseases are as inseparably associated as water and steam; and if I have failed to make this clear the fault lies with me, and not with my subject.

I fear I have already somewhat transgressed my original intentions, and will not, therefore, add anything further. The importance of the subject I have brought before you, as concerning sanitation and general medicine, cannot be more forcibly expressed than in the words of the late renowned professor of botany at Strasburg, De Barry, "a large part of all health and disease in the world is dependent on bacteria."



Fig 1.



Fig 2



Fig 3



Fig 1.



Fig 2

LIST OF ILLUSTRATIONS.

Plate IX., Fig. 1.—Plate cultivation of micro-organisms existing in the open air.

Fig. 2.—Potato cultivation of *Micrococcus prodigiosus*.

Fig. 3.—*Micrococcus prodigiosus* growing upon Agar Agar jelly.

Fig. 4.—*Micrococcus prodigiosus* growing in Koch's beef peptone jelly.

Fig. 5.—Bacillus of green pus in Koch's jelly.

Fig. 6.—White micrococcus from air upon Koch's jelly.

Fig. 7.—Pink torula from air upon Koch's jelly.

Fig. 8.—Yellow micrococcus from air upon Agar Agar jelly.


Plate X., Fig. 1.—Tube cultivation of water.

Fig. 2.—Anthrax bacilli in liver of mouse.

XXIV.—*The Dulcitone: a New and Portable Musical Instrument, having Forks of Steel for its Sound- Producers.* By Mr. THOMAS MACHELL.

[Read before the Society, 2nd May, 1888.]

ONE of our late members, Mr. Walter Macfarlane, who took a kindly interest in the experiments which resulted in the instrument submitted to the Society on 21st January, 1885, and described in *Proceedings* of that year, brought under my notice a copy of "Fors Clavigera," in which Mr. Ruskin speaks of the want of a suitable instrument for teaching children in school the true sounds within the octave. On page 260 he says :—"I have been making experiments with a view to the construction of an instrument by which very young children could be securely taught the relations of sound in the octave ; unsuccessful only in that the form of lyre which was produced for me, after months of labour, by the British manufacturer, was as curious a creation of visible deformity as a Greek lyre was of grace, besides being nearly as expensive as a piano. For the present, therefore, not abandoning the hope of at last attaining a simple stringed instrument, I have fallen back—and I think, probably, with final good reason—on the most sacred of all musical instruments, the 'Bell.'"

What I have now read led me to consider whether the principle of my invention could be rearranged in a portable form, and the result was the production of a little instrument of three octaves. On submitting it to Mr. Macfarlane, he expressed himself satisfied that it completely realised the object aimed at, and very kindly gave me an order to make one, with the intention of presenting it to Mr. Ruskin. Mr. Macfarlane desired that it should have a plain deal case, and that the compass be restricted to the notes most required in teaching singing to young children at school. This instrument, which has a compass of $2\frac{1}{2}$ octaves, lowest note F,  when completed, could not be shown to Mr. Macfarlane, who at the time was suffering from a severe illness, culminating in death the following month.

Not being satisfied with certain details of the mechanism, which on account of its novelty I found tedious and expensive to get

made satisfactorily in small quantities, I gave my attention to find out how I could best adapt and utilise the appliances already in use in the mechanism of an ordinary piano, and the result is the instrument that I shall now have the pleasure of submitting to your notice. This instrument, which I have named "The Dulcitone," has a compass of 44 notes, F to C, and has been designed to meet the want now generally felt of a portable, keyboard, percussion instrument, suitable for solo playing, for use in combination with other instruments, or with the voice; as an auxiliary to the pianoforte and organ for the practice of technical studies, and as an aid in teaching children to sing or young violinists to play in tune. The sound-producers are square rods or bars of steel, bent to the form of tuning forks (without shanks), the forks being of graduated lengths for the various musical notes. A sound-board is placed near the bottom of the case, having a bridge glued thereon, extending horizontally from end to end. Each fork is connected to the bridge on the sound-board by a piece of thin spring steel bent to the form of a semicircle, and having one end clamped to the fork by means of a pair of small plates secured by screws, whilst the other end is held by a small plate screwed to the bridge. The forks are additionally supported and kept in position at their nodes by resting in notches on a suitably-cushioned rail. The hammers rest on the central rail of the key frame, which is cushioned on its underside. The butts to which the hammers are connected are pivoted in the usual way, and fastened to the drop rail of the key frame. They are pressed down by spiral springs, which are also fastened to the drop rail. Hinged to, and depending from, regulating levers placed at the back end of each key are adjustable hoppers, which, acting on the underside of the butts, cause the hammers to strike down on the forks when the keys are pressed. The dampers act on one or both ends of each fork, and are connected by bent wires to hinged levers, which latter are supported in a position underneath the front of the keys by a wooden rail. This wooden rail also carries a guiding rail through which the wires connecting the dampers and keys pass. On the top of each wire is placed a cushioned regulating button. A hinged rail placed underneath the damper levers is actuated by another lever having its fulcrum on the inner front of the case, which brings the dampers under the control of the foot by means of a cord



passing through the front part of the case. The keys are in size and description exactly similar to those used in pianofortes.

The dulcitone in a solid mahogany case is nearly an exact duplicate of the one forwarded to Mr. Ruskin a short time ago by the present Mr. Walter Macfarlane, who most kindly desired to carry through his late uncle's intentions in this matter.

The dulcitone in ornamental case, with frets and extended end, mounted on stand, was made to a design kindly presented to me by Mr. G. A. Audsley, F.R.I.B.A., of Devon Nook, Chiswick, a gentleman who takes a friendly interest in my work, and to whom I am indebted for several valuable hints.

To Mr. Thomas Jowitt, of Sheffield, I am also indebted for valuable aid in ascertaining, by experiment, the most suitable character and quality of steel for my purpose.

Shown in illustration of this paper—

1. A sectional model of the instrument described in *Proceedings* for 1885.

2. Instrument in mahogany case—compass, 3 octaves.

3. Instrument in plain deal case—compass, $2\frac{1}{2}$ octaves.

4. Dulcitone as described to the Society.

5. Dulcitone in ornamental case, made to the design of Mr. G. A. Audsley.

XXV.—*On the application of Wind Power to the generation and storage of Electricity.* By PROFESSOR JAMES BLYTH, M.A., F.R.S.E.

[Read before the Society, 2nd May, 1888.]

IN common, I daresay, with many other persons, I have felt, for some time past, that the power of the wind was not sufficiently taken advantage of for the purpose of generating and storing electrical energy; and, in the course of last summer, I determined to make some experiments to test the point in a practical way. These consisted in the erection of a small windmill for supplying electric light by means of storage cells, to a small cottage in the village of Marykirk, Kincardineshire, where I usually spend my summer holiday. The mill was finished and working about the end of July, 1887.

The windmill is of the old English type, and is erected in the garden so as to have the best available exposure to the wind, although this is not so good as could be desired, and, indeed, in most places could easily be obtained. The tower consists of a wooden tripod firmly fixed in the ground and strongly braced together by bars of wood. The windshaft stands about 33 feet above ground, and carries four sail arms at right angles to each other, each being about 13 feet long. The canvas sails are attached to the arms, or whips, and are supported by sail bars in the usual way. By means of bevel wheels the windshaft gives motion to a long vertical shaft, from which, again, by bevel wheels, the motion is communicated to a horizontal axis which carries a fly-wheel, 10 feet in diameter, and which, of course, moves in a vertical plane. The dynamo, an old form of Bürgin, is driven directly from the fly-wheel by means of a rope, and a workable speed is attained even when the windmill moves at a comparatively slow speed. The current from the dynamo is employed to charge 12 E.P.S. storage cells, which supply the incandescent lamps in the cottage. As yet I have only used, at one time, 10 eight-candle power 25-volt lamps, but I find that storage for more can be quite easily obtained. One day last summer, when a good breeze was blowing, I stored as much in half a day

as gave me light for four evenings, about three or four hours each time. As yet, however, I have not had time or opportunity to test fully the capabilities of my arrangement. For one thing, I require a more suitable dynamo and a much greater storage capacity, so as to take advantage of all the wind that blows; and when this is done I have no doubt whatever regarding the complete success of my experiment.

While charging, the current passes through a cut-out arrangement, which immediately disconnects the cells from the charging circuit when the dynamo runs below a certain speed. In this way the windmill can be allowed to run day and night, as it will only store when a certain speed is attained, and the cells are effectually prevented from discharging themselves through the dynamo, even should it stop.

I may mention that on several occasions I have used the stored electricity to drive a small turning lathe in my workshop, and that I have begun to make a light form of carriage to be driven by the same, so that I am in hope of having some day a drive by means of stored wind energy.

One day, during last Christmas holidays, there was a good breeze and I tried, for curiosity, the experiment of direct lighting from the dynamo without the use of storage cells, the lamps being inserted as a shunt from the brushes. A fairly steady light was obtained from eight lamps, and the risk of burning them up was avoided by inserting two lamps of higher volts.

XXVI.—*On the Electrical Resistance of Slate and Marble and other Materials, with reference to their use in Electric Light Fittings.* By THOMAS SHIELDS, M.A.

[Read before the Society, 2nd May, 1888.]

THE subject of my remarks is one that not only possesses the theoretical interest which attaches to the publication of fresh information on any subject, but is also practically interesting in connection with its relation to electric lighting.

It would be difficult at the present moment to forecast the issue of the struggle between the partisans of the transformer system, and those of the accumulator system, of electrical distribution; but if, as is not at all unlikely, the transformer system comes to be established, as for many purposes at once the most convenient and most economical system for the distribution of electricity, then it is obvious that the question of good insulation in the circuit will become one of even greater importance than it is at present. A system of insulation, for example, which was found quite satisfactory with a working potential of 100 volts, might speedily show signs of weakness and break down under a potential of 3000 volts.

The first point, of course, in the insulation of an electric circuit to be looked to is the insulation of the leads, but that forms no part of my subject. The next point is the insulation of any break or interruption in the leads, and it is here we find that faults by far most frequently occur and insulation breaks down. It is not, as a rule, in the insulation of the conductors themselves that faults occur, but in the insulation of the switches, fuses, cut-outs, electrical measuring instruments, &c., that are inserted in the circuit. On the authority of Mr. Addenbroke, at least 95 per cent. of the faults that occur have this origin. It is most important, therefore, to ensure that there is good insulation in these cases. The materials that have been chiefly used to secure this are slate and porcelain. The latter is open to the very serious objection of being easily cracked and broken. There are objections also to the use of slate, which will be considered later on. Its cheapness, however, together with its cleavage, which renders it capable of

being easily split into slabs, and the comparative ease with which it can be worked generally, have gone far to bring slate into favour for this purpose. The object of the investigation, the results of which I now set before you, was, in the first place, a determination, good enough for practical purposes, of its merits as an insulator compared with other materials which might conveniently be used for the same purpose.

As regards the methods of measurement, I adopted those which are in common use in cable-testing. When the resistance was comparatively low it was measured by means of a high-resistance mirror galvanometer by comparison with a known resistance. The connections of the apparatus used are shown in Fig. 1, Plate XL.

The resistance to be measured is denoted by R ; CO are two contact pieces of equal area; G is the galvanometer, and S an adjustable resistance arranged as a shunt between the terminals of the galvanometer; B is the battery, and K an ordinary make-and-break key. On depressing the key, the current which passes through R is measured by the galvanometer; R is then replaced by a known resistance and the current which passes through it is measured. We thus get a comparison of the two resistances by comparing the currents which the same electro-motive force gives in the circuits of which they successively form part.

Let E denote the difference of potential between the terminals of the battery; R , the resistance to be measured; G , the resistance of the galvanometer; and d , the deflection obtained when the galvanometer is shunted with a resistance, S ; and let R_1 , S_1 , and d_1 denote the corresponding quantities when the unknown resistance, R , is replaced by the known resistance, R_1 .

Suppose that no shunt is used, then the current which passes through the galvanometer will be equal to $\frac{E}{R}$; but when the galvanometer is shunted with a resistance, S , the current will divide, and the part which passes through the galvanometer will be equal to $\frac{S}{S+G} \times \frac{E}{R}$. And since the deflection on the scale is proportional to the current which passes through the galvanometer, we get the equation—

$$\frac{S}{S+G} \times \frac{E}{R} = C \times d \quad \dots \dots \dots (1)$$

where C is a constant quantity

Similarly, when the known resistance is inserted in the circuit we have—

$$\frac{S_1}{S_1 + G} \times \frac{E}{R_1} = C \times d_1, \quad - \quad - \quad - \quad - \quad - \quad (2)$$

Hence, combining these two equations, we get—

$$\frac{\frac{S_1}{S_1 + G} \times \frac{E}{R_1}}{\frac{S}{S + G} \times \frac{E}{R}} = \frac{C \times d_1}{C \times d}, \quad - \quad - \quad - \quad - \quad - \quad (3)$$

Solving equation (3) for R, we have—

$$R = \frac{d_1 \times R_1 \times S \times (S_1 + G)}{d \times S_1 \times (S + G)}, \quad - \quad - \quad - \quad - \quad - \quad (4)$$

which gives us R in terms of known quantities, and we can thus proceed to calculate it. This value, R, is obviously directly proportional to the area of the contact pieces, and inversely proportional to the thickness of the material between them. The specific resistance, therefore, or resistance per cubic centimetre of the material, will be equal to $\frac{R \times A}{l}$, where A is equal to the area of contact in square centimetres, and l , the thickness in centimetres. Hence, if the resistances are given in ohms, the resistance between two opposite faces of a cubic centimetre of the material will be equal to $\frac{R \times A}{l}$ ohms.

Some of the materials tested, however, had too high a resistance to give a readable deflection on the galvanometer scale, and these had to be measured electro-statically by the quadrant electrometer. The method of joining up is shown in Fig. 2. A quadrant electrometer, Q, a standard condenser, K, and the resistance to be measured and contact pieces (which form a condenser), R, are all joined up in parallel with the charging condenser, C, so that one side of the apparatus, being joined to earth, is always at zero potential, while the other side is insulated perfectly in every respect except as regards R, the insulator whose resistance is to be measured. The insulated side is charged by depressing the key, k . Contact is made for half a minute, and the deflections on the electrometer scale are noted every half minute thereafter. We thus get the time-rate of the leakage through the insulator, R.

MEASUREMENTS OF THE CAPACITY OF SLATES FOR ABSORBING RADIATION

It is well known that the capacity of a substance for absorbing radiation is a function of its physical properties, and it is the purpose of this paper to determine the capacity of slates for absorbing radiation.

$$\begin{aligned} \frac{dQ}{dt} &= \frac{d}{dt} \left(\frac{1}{2} \rho V c \Delta T \right) \\ &= \frac{1}{2} \rho V c \frac{d\Delta T}{dt} \\ &= \frac{1}{2} \rho V c \frac{dT}{dt} \end{aligned}$$

where ρ is the density of the slate, V is the volume of the slate, c is the specific heat of the slate, and ΔT is the change in temperature of the slate.

$$\begin{aligned} \frac{dQ}{dt} &= \frac{1}{2} \rho V c \frac{dT}{dt} \\ &= \frac{1}{2} \rho V c \frac{dT}{dt} \end{aligned}$$

$$\frac{dQ}{dt} = \frac{1}{2} \rho V c \frac{dT}{dt}$$

The slates used were of a variety of sizes and shapes, and the measurements were made at different temperatures. It is found that the capacity of slates for absorbing radiation is a function of the temperature of the slate, and the results are given in the following table.

The slates used were of a variety of sizes and shapes, and the measurements were made at different temperatures. It is found that the capacity of slates for absorbing radiation is a function of the temperature of the slate, and the results are given in the following table.

In Table I, there are shown the results of the first set of experiments. These measurements were made at the ordinary temperature of the Physical Laboratory of Glasgow University, and were ordinary atmospheric conditions generally, the only precaution being the various slates received being a careful cleaning of their surfaces.

TABLE I.

MARKS.	MATERIAL.	SPECIFIC RESISTANCE.	
		In Megohms.	In C.G.S. Units.
I.	Slate, - - - -	14·84	1484×10^{12}
II.	Slate, - - - -	18·5	1850×10^{12}
III.	Serpentine, - - -	46·15	4615×10^{12}
IV.	Carboniferous limestone, -	265	2650×10^{14}
V.	Black marble, - - -	1027	1027×10^{12}
VI.	Fluorite, - - - -	4285	4285×10^{12}
VII.	White marble, - -	7998	7998×10^{12}

The noticeable feature of these results is the comparatively low resistance of slate and the very high resistance of common white marble. The high insulation of the fluorite may have been partly due to the fact that the specimen tested was polished on both sides, but I have been unable as yet to verify this.

The same specimens were then baked for three hours over a sand-bath and again tested. As I have mentioned already, these preliminary experiments were for the purpose of arriving at a speedy determination good enough for practical purposes, and, consequently, no means were adopted to ascertain the temperature of the slabs when their resistance was measured. It was greater, however, than under ordinary conditions they would be subjected to in practice, and, inasmuch as each specimen was subject to exactly the same treatment, the figures in Table II. may be regarded as comparable to a great extent.

TABLE II.

MARKS.	MATERIAL.	SPECIFIC RESISTANCE.	
		Megohms.	C.G.S. Units.
I.	Slate, - - - -	8·7	87×10^{14}
III.	Serpentine, - - -	37·0	37×10^{12}
V.	Black Marble, - - -	20,000·0	20×10^{12}
VII.	White Marble, - -	19,000·0	19×10^{12}

The various materials were next subjected to a process of paraffining. They were suspended in boiling paraffin for about six hours in such a way that, while the under surface was immersed in the paraffin, the bulk of the slab was exposed to the air. By this arrangement it was hoped that the air and moisture in the various slabs would be completely expelled by the paraffin. The success of this process varied considerably with different materials, and this point is particularly interesting in view of some remarks made recently relative to this subject at a meeting of the Society of Telegraph Engineers and Electricians. It was in the discussion a few months ago on Mr. Cockburn's paper on "Safety Fuses," in which Mr. Crompton stated that slate when soaked in paraffin made an almost perfect insulator. Instead of this I found that slate scarcely absorbed paraffin at all: the paraffin, indeed, owing to surface action, soon overspread the slate, but it did not penetrate into the material. And so, indeed, it was found when the paraffin was removed from the surface and the slate again tested, that the resistance remained the same as it was when in the normal condition. Consequently, it was on the thin coating of paraffin that Mr. Crompton had to depend for his insulation, and not on the slate itself. It was found, moreover, that serpentine absorbed the paraffin only to a very slight extent, but that white marble readily absorbed it. In the latter case there was another curious and also practically important effect of the paraffining process, which had a hardening effect on the marble, rendering it much less easily breakable. The effects of the paraffin on the insulating qualities of the various materials are shown in Table III.

TABLE III.

Marks.	Material.	SPECIFIC RESISTANCE.	
		Megohms.	C.G.S. Units.
I.	Slate, - -	14	14×10^{15}
III.	Serpentine, -	83	83×10^{15}
V.	Black marble, -	8,000	80×10^{17}
VII.	White marble, -	5,000,000	50×10^{20}

All these figures point to the superiority of marble as an insulator, and there is no reason against its occupying the place which slate at present holds in electric light fittings, and almost every reason in its favour.*

Although valuable from a practical point of view, the figures which I have given do not, however, represent the true insulating value of the materials, inasmuch as the measurements were made in the presence of some moisture at least, or else of paraffin. My next object, therefore, was to get rid of moisture entirely and secure a measurement which would represent the specific resistance of the materials themselves. The arrangements made to effect this are shown in Fig. 3, which sufficiently explains itself. Arranged as before, the insulator and contact pieces are enclosed in a tin-plate box, which, in its turn, is enclosed in a sand-bath. The conductor from one of the contact pieces is led through a wide glass tube to the insulated quadrants and the other conductor is led to earth. The arrangements for testing are the same as those shown in Fig. 2. The apparatus in Fig. 3 was heated up to about 200° C. and kept at that temperature for some hours. All the moisture expelled from the insulator was absorbed by strong sulphuric acid placed in a vessel in the inner box. As the insulator was allowed to cool, readings were taken at intervals, and the specific resistance at various temperatures deduced. The curves in Fig. 4 are plotted from the values obtained for slate and marble at various temperatures, and may, I think, be regarded as giving the specific resistance at those temperatures of the materials themselves free from moisture.

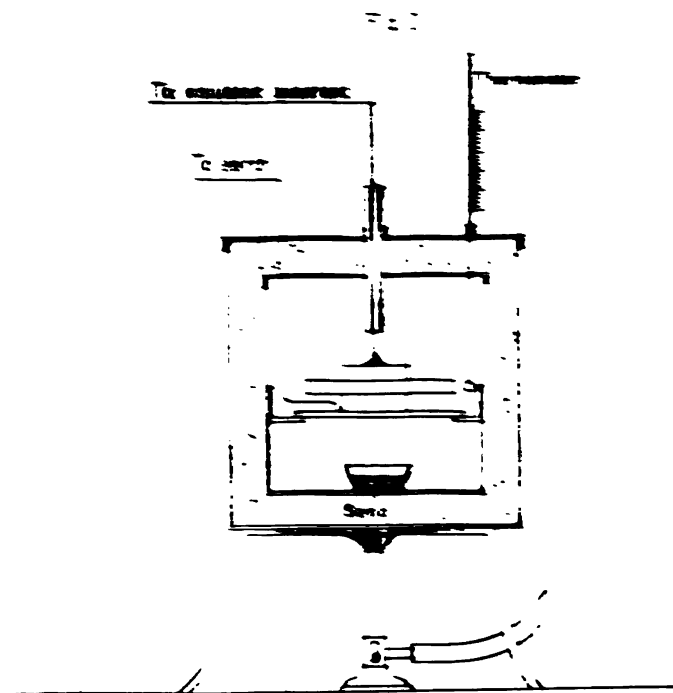
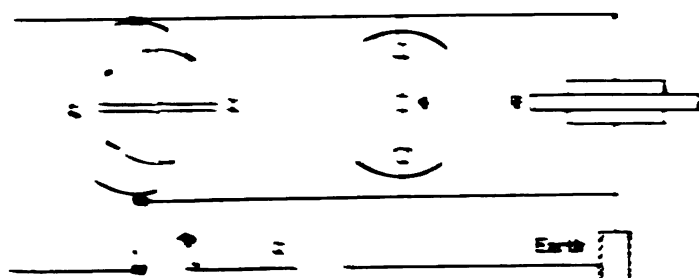
Finally, it may be interesting to observe how these materials compare as insulators with glass. Table IV. gives the specific resistance at 100° C. of slate and marble and some kinds of glass, varying in density and percentage composition. The figures for glass in this Table are taken from Messrs. T. Gray and J. J. Dobbie's paper "On the Electrical Qualities of Glass," in the *Proceedings of the Royal Society* for 1884.

* Since this paper was read the President of the Vienna Society of Electricians, who officially inspected the underground system in connection with the lighting of the Burg Theatre, Vienna, recently completed, has stated that the only defective insulation in the system existed in the slate supports of the cut-outs, and of the other apparatus of this kind.

TABLE IV.

Material	Density	Percentage absorptions		Specific resistance at a temp. of 1000° C. in absolute units.
		50%	75%	
Alum.	2.41	47.5	40.5	34×10^{21}
"	2.43	53.7	37.1	47×10^{21}
"	2.54	22.7	20.5	5.34×10^{21}
"	2.71	22.3	19.3	4.53×10^{21}
Vitre Mar.	..	..	..	2.15×10^{21}
Slate	..	..	..	0.54×10^{21}

ON THE ELECTRICAL RESISTANCE OF SLATE AND MARBLE



ON THE ELECTRICAL RESISTANCE OF SLATE AND MARBLE.

Fig 1.

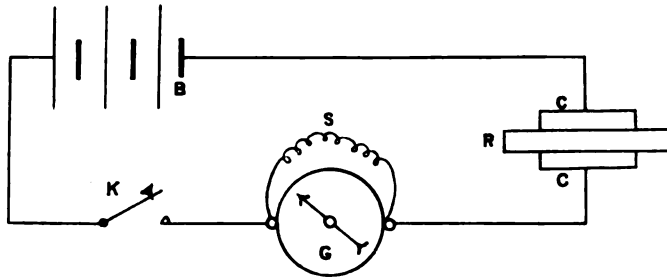
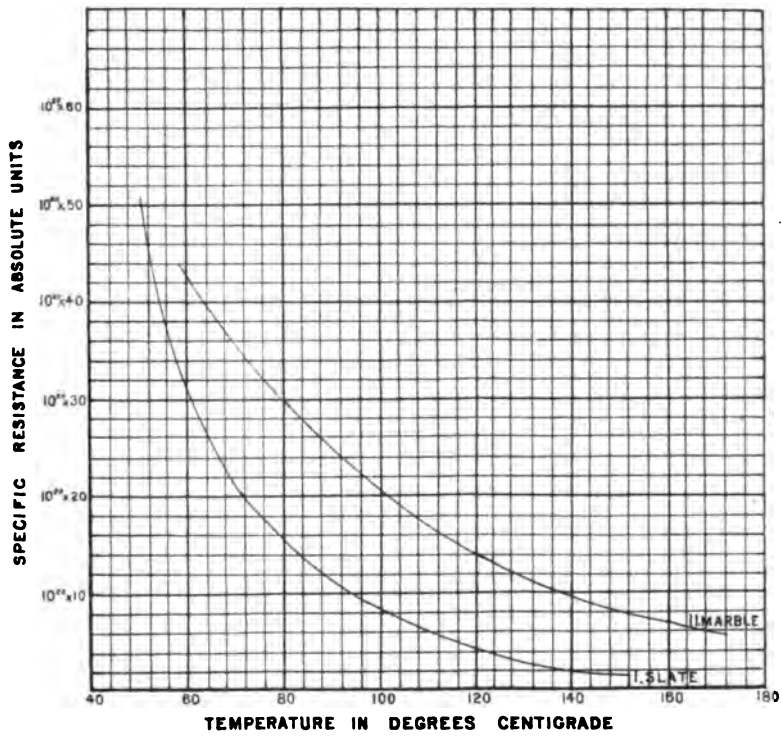


Fig. 4



REPORT OF THE SOCIETY'S REPRESENTATIVE AT THE GLASGOW AND
WEST OF SCOTLAND TECHNICAL COLLEGE.

[Read before the Society, 2nd May, 1888.]

JOHN MAYER, Esq.

2nd May, 1888.

DEAR SIR,—For the information of the President, Council, and Members of the Philosophical Society, I beg to report that, as the representative of the Society, I have attended thirty-three meetings of the Governors of the Glasgow and West of Scotland Technical College.

The amalgamation of old and rival institutions has necessarily been a work of time and labour, but I am now glad to report that my able colleagues are working in a most harmonious way for the interests of the College, and that much excellent work has been done in extending the scope and number of the classes, both in the day departments and evening class departments of the College proper, and in the School attached to the College known as "Allan Glen's."

In regard to the latter, extensive additions have been arranged for the Buildings, and also much-needed repairs and additions of apparatus have been made both in the Bath Street and the Andersonian Buildings.

The attendance at the classes during the present session has been quite as large as anticipated by the Governors.

It is hoped that the generous support of the public will be forthcoming in providing funds for improving the position of the College as regards its buildings, which are far behind those of other towns in appearance and accommodation for the students, a finer body of whom scarcely exists in the United Kingdom, measured by their success at examinations.

Finally, I have to draw attention to the new Calendar of the College which will shortly be issued, and which embodies the arrangements for the new session and thereafter, the details of which, especially as regards the various curricula for diplomas, have had a deal of our anxious consideration.

Yours faithfully,

J. J. COLEMAN.

REPORT OF DELEGATE TO THE BRITISH ASSOCIATION—
MANCHESTER, 1887.

[Communicated to the Society, 2nd May, 1888.]

Last Session the Council of this Society appointed its former President, Dr. Muirhead, its delegate to attend the Meeting of the British Association at Manchester. Dr. Muirhead was not in his usual health, and he desired me to act as delegate for him. This I did, and I have now to make a short report of the chief business at the meetings of the delegates of the Corresponding Societies of the British Association. The official report of the proceedings may be seen in the "Report of the British Association" for the year.

These annual meetings of delegates from scientific societies were arranged three years ago for the purpose of securing more co-operation amongst local societies than had existed previously, and of directing their work to a number of desirable subjects, which could be wrought out best under a common plan.

The subjects referred to at the meetings of delegates I shall arrange under the different sections to which they belong. There were two meetings and thirty-two delegates, of whom seven were from Scotch societies.

I. PHYSICS.

Temperature Variation in Lakes, Rivers, and Estuaries.—Societies situated in the neighbourhood of these might do useful work by getting some of their members to take daily or weekly observations of temperature. Rules are to be drawn up for this purpose, and observers willing to undertake the work are desired to communicate with Dr. J. Murray, Secretary of this Committee, "Challenger" Office, Queen Street, Edinburgh.

Earth Tremors.—Professor Lebour said that Corresponding Societies might do good work by establishing a great network of seismoscopes and seismographs. A seismoscope could be bought for £2, and a seismograph for £25. The Secretary of this Committee, Professor Lebour, College of Physical Science, Newcastle-

on-Tyne, said he would be glad to communicate with anyone interested in the subject.

II. GEOLOGY.

Underground Water.—Information is required as to “depth of wells, sections passed through, the height at which water stands before and after pumping, daily records of height, and chemical analysis of water.” Circular forms of inquiry can be obtained from C. E. de Rance, 28 Jermyn Street, London, S.W.

Erratic Blocks.—Size, character, and position should be marked on one-inch Ordnance Map. Circular forms of inquiry of Rev. Dr. H. W. Crosskey, 117 Gough Road, Edgbaston, Birmingham.

Sea Coasts Erosion.—Particulars and forms of inquiry are supplied by William Topley, 28 Jermyn Street, London, S.W.

III. BIOLOGY.

Life-Histories of Plants.—A letter was read from Professor Bayley Balfour, in which it was urged that much good scientific work might be done by local societies by encouraging their members to “study the life-histories of indigenous plants in their entirety, that is to say, from the stage of embryo in the seed up to the production of fruit and seed again.” As examples of contributions of such a kind, those of Lubbock, Hermann, Müller, Kerner, and Ogle were mentioned, and special attention was directed to the work done by Wydler and Irmisch on the native plants of Germany.

Provincial Museums.—The Committee had been engaged collecting particulars of museums out of London, and they intend to visit all the local museums of Germany, France, and America.

IV. ANTHROPOLOGY.

Prehistoric Remains.—Good service could be rendered by inducing proprietors of such remains to communicate with General Pitt-Rivers, the Inspector of Ancient Monuments, 4 Grosvenor Gardens, London, S.W., with the object of placing these remains under government protection. This, the Chairman said, applied particularly to Scotland. The recommendations General Pitt-Rivers wished to make were these:—Local societies should (1) report to him what monuments in their district they think worthy of being put under the Act; (2) they should send him the names

and addresses of the owners; (3) they should communicate with the owners, and, if possible, obtain their consent to have the monuments placed under the Ancient Monuments Act; and (4) they should report to him any damage being done to such monuments, or contemplated. With such assistance he thinks much more rapid progress may be made.

W. C. CRAWFORD.

REPORTS OF SECTIONS.

SESSION 1887-88.

[Received at Meeting of Society on 2nd May, 1888.]

1. REPORT OF THE ARCHITECTURAL SECTION.

During the Session eight Meetings have been held, at which nine papers have been read. The following is a list of the papers read at the Meetings :—

Monday, November 14, 1887.—Opening Meeting, when Mr. James Thomson, architect, F.R.I.B.A., President of Section, gave his Address, subject, “Remarks on the Architecture of Glasgow during the past Fifty Years.”

Monday, November 28, 1887.—Mr. Francis H. Newberry, Glasgow School of Art, read a paper on “The Training of Architectural Students.”

Monday, December 12, 1888.—Mr. T. L. Watson read a paper on “Fire Prevention and exits from Public Buildings.”

Monday, January 16, 1888.—Mr. George H. Laird, wright, read a paper on “Wright Work;” and Mr. Alexander Brown, plumber, read a paper on “Plumber Work, Past and Present.”

Monday, January 30, 1888.—Mr. Thomas Gildard, architect, read a paper on “Greek Thomson.”

Monday, February 13, 1888.—Mr. Robert Brydall, St. George's Art School, read a paper on “Early Sculpture in Scotland.”

Monday, February 27, 1888.—Mr. Harry W. Chubb, of London, read a paper on “Ancient, Mediæval, and Modern Locks and Keys.”

Monday, March 12, 1888.—Mr. Andrew Black read a paper on “Iron Construction as adapted to Building Purposes.”

The thanks of the Section are due to all those gentlemen.

During the Session 10 Associates joined the Section.

The Annual Business Meeting was held on Monday, March 12, when the following gentlemen were elected to office:—

President—Mr. James Thomson, architect.

Vice-Presidents—Mr. Thomas Gildard and Mr. R. A. M'Gilvray.

Treasurer—Mr. James Howatt.

Secretary—Mr. A. Lindsay Miller, architect.

Members of Council—Messrs. James Sellars, architect; David Thomson, architect; T. L. Watson, architect; David MacBean, architect; James Chalmers, architect; William Howatt, measurer, Alexander Muir, builder; William Gilfillan, marble cutter; Andrew Black, smith; William Cairns, plumber.

(Signed) A. LINDSAY MILLER,
Hon. Secy. of Section,
 121 WEST REGENT STREET.

2. REPORT OF THE GEOGRAPHICAL AND ETHNOLOGICAL SECTION.

Two papers from the Section were read before the Society during the Session. The first was on "Burmah," by Mr. A. Colquhoun. This was read at a joint Meeting of the Society and the Chamber of Commerce, held in the Hall of the Society, on the evening of Friday, 11th November. It was illustrated by a number of lime-light views. The second, on "The River Plate System," by Mr. John Galloway, was read at the Society's Meeting on 7th March, and is printed in the *Proceedings*. In addition to these, two Meetings were held under the arrangement for holding joint Meetings with the Glasgow Branch of the Scottish Geographical Society, at which the following papers were read:—1st, "The Antarctic Regions," by Mr. A. Silva White, on 18th January; 2nd, "Attempts to reach the Owen Stanley Peak," by Mr. H. O. Forbes, on 3rd April. Mr. Forbes' lecture was given in the Reception Room, Queen's Rooms, and was illustrated by lime-light views of New Guinea, and by a large collection of curios and birds.

Office-Bearers for 1887-88.

President—W. G. Blackie, Ph.D., LL.D., F.R.G.S.

Vice-Presidents — James Stevenson, F.R.G.S.; Sir Michael Connal, Thomas Muir, M.A., LL.D., F.R.S.E.

Secretary and Treasurer—G. A. Turner, M.D., C.M.

Members of Council.—Mr. Jas. Grierson, Mr. Maxwell Hannay, Mr. Wm. Ker, Mr. Jacques Van Raalte, Mr. Alex. Scott, Mr. W. Renny Watson, Mr. Robt. Blyth, C.A.; Mr. George Miller, Mr. Jas. Christie, A.M., M.D.; Mr. William Ewing, Mr. Nathaniel Dunlop, Mr. Robert Gow.

(Signed) GEO. A. TURNER, M.D.,
 Secretary.

3. REPORT OF THE BIOLOGICAL SECTION.

The Section held no Meetings of its own during the Session.

Professor M'Kendrick read a paper before the Society on "The Modern Cell Theory," and gave demonstrations of (1) a Spectropolarimeter; (2) a Gas Pump for extracting Air from the Blood; (3) a Centrifugal Apparatus for separating Blood Corpuscles; (4) an Electro-myographion.

Mr. Maylard gave a demonstration on "Bacteriology."

(Signed) JOHN YULE MACKAY, M.D.,
 Secretary.

4. REPORT OF THE MATHEMATICAL AND PHYSICAL SECTION.

At the Annual General Meeting of the Society, held on the 16th November, 1887, the following Office-Bearers were appointed to the Mathematical and Physical Section:—

President—Sir William Thomson, LL.D., F.R.S., &c.

Vice-Presidents—Thomas Muir, M.A., LL.D.; and Professor Robert Grant, LL.D., F.R.S.

Secretary and Treasurer—Mr. Thomas Gray, B.Sc., F.R.S.E.

Members of Council—Mr. Peter Alexander, M.A.; Professor James Blyth, M.A.; Mr. James T. Bottomley, M.A.; Mr. Henry Dyer, M.A., B.Sc.; Professor William Jack, LL.D.; Professor Andrew Jamieson, F.R.S.E.; Professor James Thomson, F.R.S.; Mr. Magnus Maclean, M.A.; Mr. James Wood, M.A.

The Section has contributed three papers to the Society during the Session, and the following new Associates have been elected:—

Mr. J. H. Gray, Mr. W. Leckie, Mr. Andrew W. Meikle, Mr. James Erskine Murray, Mr. Thomas Shields, Mr. Malcolm Sutherland.

(Signed) THOMAS GRAY,

Secretary,

PHYSICAL LABORATORY, UNIVERSITY OF GLASGOW.

5. REPORT OF THE CHEMICAL SECTION.

The Associates have during the past Session been invited by post-card to the periodical Meetings of the Glasgow and West of Scotland Branch of the Society of Chemical Industry. No papers have been directly contributed to the Section during the Session.

The fact of the existence of the above-named Society, together with the establishment some time ago of a large Chemical Society, similar in its aims to our Section, in connection with one of the principal educational institutions of the City, accounts for the absence of progress in our Chemical Section.

There are ten Associates on the roll, one of whom during the Session joined the Membership of the Philosophical Society.

(Signed) JOHN TATLOCK,

Secretary.

6. REPORT OF THE SANITARY AND SOCIAL ECONOMY SECTION.

A Meeting of the Section was held on 16th November, 1887, at which the following Office-Bearers were elected:—

President—Eben. Duncan, M.D., 4 Royal Crescent, Crosshill.

Vice-Presidents—James Christie, M.D., 2 Great Kilmartin Terrace; and John Glister, M.D., 4 Grifton Place.

Members of Council—Messrs. Alex. Frew, 175 Hodge Street; Neil Carmichael, M.D., 59 South Cumberland Street; W. R. W. Smith, 6 South Hanover Street; John Young, 234 Parliamentary Road; James Chalmers, 111 St. Vincent Street; Peter Fyfe, 1 Montrose Street; Walter Arnold, 15 Dixon Street; Alex. Scott, 2 Lawrence Place; W. P. Guthrie, 51 Lennox Street; J. C. Burns, 39 Jamaica Street; John Honeyman, 141 Bath Street; and H. K. Brownhead, 145 St. Vincent Street.

It was agreed to recommend that papers by the following gentlemen be read before the Society during the Session viz:— (1) Paper by Mr. John Honeyman; 2. Paper by Mr. Peter Fyfe. Mr. Honeyman was unfortunately unable to complete his paper in time for this Session. Mr. Fyfe read his paper before the Society on 11th April 1915, the subject being "Important Points in the Sanitary Work of a great City."

The Section has been occupied during the latter part of the Session with the Memorial to be presented to the Secretary for Scotland on 1. the Amendment of the Burials Act; 2. Consideration of other means than the present for the disposal of our dead.

Signed W. R. M. CLEVELL

Secretary.

75 ST. GILES PLACE.

7. REPORT OF THE ECONOMIC SCIENCE SECTION.

The Economic Science Section has held eleven Meetings during the Session, and has sent one communication to be read before the Philosophical Society. Several Associates have retired and several have joined during the Session, the total number being now 61, or three more than at the close of last Session. One Associate has become a Member of the Society, and some of the Members who have joined the Society during the present Session have done so on account of their interest in the work of this Section.

The following is a statement of the work accomplished during the Session:—

Monday, November 7, 1887.—Paper on “Railway Rates,” read by Mr. Mark Davidson, M.A., LL.B., advocate.

Wednesday, November 11, 1887.—Paper on “Factory Industry and Socialism,” read by Mr. Wm. Smart, M.A., before the Philosophical Society.

Monday, November 21, 1887.—Meeting for the discussion of Mr. Smart’s paper.

Monday, December 5, 1887.—Paper on “Co-operative Production and Profit Sharing,” by Mr. James Mavor.

Thursday, January 12, 1888.—Paper on “Free and Fair Trade,” by Mr. Stephen Mason, M.P.

Monday, January 23, 1888.—Paper on “Godin’s Familistère,” read by Mr. J. Murray Templeton.

Monday, February, 6, 1888.—Paper on “American Currency,” read by Mr. And. S. McClelland.

Monday, February 20, 1888.—Paper on “The Constitution and Course of the Money Market,” read by Mr. Charles Gairdner, President of the Section.

Monday, March 5, 1888.—Paper on “Emigration,” read by Mr. Walter W. Blackie, B.Sc.

Monday, March 19, 1888.—Paper on “Preventible Bankruptcies,” by Mr. John Mann, jun., M.A., C.A.

Thursday, April 5, 1888.—Paper on “Some of the Social and Economic Aspects of the Welsh Land Question,” read by Professor H. Jones, M.A., of University College, Bangor.

Three new Members have been added to the Council, namely:—Mr. George Barclay, Mr. Chas. E. Beckett, M.A., LL.B.; Mr. James Marr.

(Signed) WALTER W. BLACKIE,
 Hon. Secy. of Section.

MEMOIR OF MR. DAVID SANDEMAN.*

DAVID SANDEMAN was born at Edinburgh in 1814. After receiving his education there he went to London, and spent several years in business houses in the Metropolis before founding the Glasgow firm with which his name was so long and so honourably identified. During the greater part of his life in this city he took a deep interest in the cause of Technical Education. The frequent visits he paid to France and Germany enabled him to obtain a clear insight into the principles on which this important branch of education is conducted on the Continent, and to appreciate the advantages it confers on foreign manufacturers. It was the earnest desire he felt for the enjoyment of similar advantages in our own country that led him to become a warm advocate and promoter of the movement inaugurated in Glasgow in 1837, for the establishment of a Technical College. He joined the first committee appointed for this purpose, under the presidency of Mr. Thomas Montgomerie Neilson, and became one of its most zealous members. Without dwelling at length on the history of the labours of the committee, the fact may be recalled, that it directed its efforts to the formation of an institution which should not only provide for the education of the youth of Glasgow, but should also extend its influence to the outlying districts, and more especially to the manufacturing towns of Dumbarton, Ayr, and Glasgow. An industrial school was a valuable and important part of the technical education, and it was also formed part of the committee's programme. At first it was thought that the old Glasgow High School, the site of which might be utilized as the nucleus for the new institution, and the buildings of the Technical College, and the industrial school, might be made with the necessary alterations, and the necessary additions. It being found, however, that the alterations and additions could not be made with the necessary economy, the committee decided to draw up a more complete plan for a new building, and a new building was erected on the site of the old Glasgow High School, and the new building is a handsome and commodious structure, and is now a well-known and important part of the Glasgow Technical College.

The committee, however, did not stop at the erection of the building. They pointed Mr. Sandeman as the first principal of the Glasgow Technical College.

himself heartily into the work, but, though he obtained the promise of large sums from many who were foremost in the cause, and subscribed liberally himself, the fund did not exceed £12,000. Some members of the committee became discouraged at the want of success, and talked of abandoning the project altogether; but Mr. Sandeman was determined that it should not fall to the ground. He argued in favour of at least one branch of the Technical College, the Weaving School, being organised; and, finding able supporters in Mr. Montgomerie Neilson and others, he was authorised by the committee to call up a portion of the subscriptions. Even this was found no easy task, but after a prolonged struggle, in which Mr. Sandeman obtained able assistance from Mr. Frame, the secretary of the College, a fund of £4,500 was secured. Early in 1874 Mr. Sandeman and Mr. Templeton were appointed to look out for a site for the Weaving School, and, with the approval of the trustees, a small piece of ground was purchased in Well Street, Calton, a locality considered the most suitable in Glasgow on account of the majority of the weaving factories being situated in the neighbourhood. A weaving shed, lecture rooms, and offices were erected, and the school was opened in September, 1877, by Sir James Bain, then Lord Provost of Glasgow. It was supposed that probably about twenty pupils might attend the school, but in the very first session this number was more than doubled. Since then the average number of pupils has been sixty. Manufacturers have borne testimony to the great advantages of the practical instruction given at the school by making a certificate of attendance a recommendation for entering their employment. It is also satisfactory to know that the site, the building, and its contents are almost entirely free from debt. For all these results great credit must be given to many of our leading citizens, as well as to the Worshipful Company of Clothworkers, London. Beyond all question, however, the prosperity of the institution is mainly due to the energy and indomitable perseverance which Mr. Sandeman threw into the undertaking.

In other educational establishments of our city Mr. Sandeman took a very warm and active interest. He was for many years a Director of Anderson's College. He was also President of the Mechanics' Institute from 1873 to 1878, and continued to be a Director until 1883 not only of the Mechanics' Institute, until it was reconstructed in 1880, but also of the College of Science and Arts. Besides taking a share in the management of these

institutions, he subscribed most heartily every year for prizes to be distributed amongst the most deserving pupils, and in 1882 he presented a very handsome gold medal for competition amongst the engineering students. Mr. Sandeman long advocated the amalgamation of the various technical schools of the city under one governing body, and had the gratification some time before his death of witnessing the fruition of his efforts in this direction by the establishment of the Glasgow and West of Scotland Technical College, embracing Anderson's College, the College of Science and Arts, and Allan Glen's School. The Weaving School is not yet included in the Glasgow and West of Scotland Technical College, although provision is made in the Scheme for this being done. In the meantime, however, the instruction given in the Weaving School forms a part of the curriculum in "Textile Industries" in the College.

In many of the industrial, benevolent, and literary institutions of Glasgow Mr. Sandeman likewise took a leading part. He was a member of the Chamber of Commerce, and for many years one of its directors. At the City Parochial Board he long had a seat. He was connected with the old Glasgow Public Library, and became one of the directors on the amalgamation, in 1871, of the library with Stirling's. In 1875 he was elected treasurer of Stirling's Library, and remained in that office until his death. Mr. Sandeman was also a member of the Archæological Society, which he joined in 1879, and acted as a member of the Council from 1880 to 1886. In the pursuit of geology he took a lively interest. Becoming a life member of the Geological Society in 1861, he afterwards served on the Council, and acted at one time as its vice-president. Though he did not contribute any original papers to the Geological Society, he had more than a superficial knowledge of the subject; and all visitors to Woodlands will remember the keen delight with which he was wont to exhibit his own admirable collection of fossils, mostly derived from the West of Scotland.

Mr. Sandeman became a member of the Philosophical Society in 1870, and took a very active interest in its work, especially in so far as that was connected with technical education. On this subject he read several papers before the Society, which were very fully discussed at the time, and did much to rouse public opinion as to the necessity for steps being taken to keep the industries of the country on a level with those of our Continental rivals.



Fig 1



Fig 2

LIST OF ILLUSTRATIONS.

Plate IX., Fig. 1.—Plate cultivation of micro-organisms existing in the open air.

Fig. 2.—Potato cultivation of *Micrococcus prodigiosus*.

Fig. 3.—*Micrococcus prodigiosus* growing upon Agar Agar jelly.

Fig. 4.—*Micrococcus prodigiosus* growing in Koch's beef peptone jelly.

Fig. 5.—Bacillus of green pus in Koch's jelly.

Fig. 6.—White micrococcus from air upon Koch's jelly.

Fig. 7.—Pink torula from air upon Koch's jelly.

Fig. 8.—Yellow micrococcus from air upon Agar Agar jelly.


Plate X., Fig. 1.—Tube cultivation of water.

Fig. 2.—Anthrax bacilli in liver of mouse.

XXIV.—*The Dulcitone: a New and Portable Musical Instrument, having Forks of Steel for its Sound- Producers.* By Mr. THOMAS MACHELL.

[Read before the Society, 2nd May, 1888.]

ONE of our late members, Mr. Walter Macfarlane, who took a kindly interest in the experiments which resulted in the instrument submitted to the Society on 21st January, 1885, and described in *Proceedings* of that year, brought under my notice a copy of "Fors Clavigera," in which Mr. Ruskin speaks of the want of a suitable instrument for teaching children in school the true sounds within the octave. On page 260 he says :—"I have been making experiments with a view to the construction of an instrument by which very young children could be securely taught the relations of sound in the octave ; unsuccessful only in that the form of lyre which was produced for me, after months of labour, by the British manufacturer, was as curious a creation of visible deformity as a Greek lyre was of grace, besides being nearly as expensive as a piano. For the present, therefore, not abandoning the hope of at last attaining a simple stringed instrument, I have fallen back—and I think, probably, with final good reason—on the most sacred of all musical instruments, the 'Bell.'"

What I have now read led me to consider whether the principle of my invention could be rearranged in a portable form, and the result was the production of a little instrument of three octaves. On submitting it to Mr. Macfarlane, he expressed himself satisfied that it completely realised the object aimed at, and very kindly gave me an order to make one, with the intention of presenting it to Mr. Ruskin. Mr. Macfarlane desired that it should have a plain deal case, and that the compass be restricted to the notes most required in teaching singing to young children at school. This instrument, which has a compass of $2\frac{1}{2}$ octaves, lowest note F,  when completed, could not be shown to Mr. Macfarlane, who at the time was suffering from a severe illness, culminating in death the following month.

Not being satisfied with certain details of the mechanism, which on account of its novelty I found tedious and expensive to get

made satisfactorily in small quantities, I gave my attention to find out how I could best adapt and utilise the appliances already in use in the mechanism of an ordinary piano, and the result is the instrument that I shall now have the pleasure of submitting to your notice. This instrument, which I have named "The Dulcitone," has a compass of 44 notes, F to C, and has been designed to meet the want now generally felt of a portable, keyboard, percussion instrument, suitable for solo playing, for use in combination with other instruments, or with the voice; as an auxiliary to the pianoforte and organ for the practice of technical studies, and as an aid in teaching children to sing or young violinists to play in tune. The sound-producers are square rods or bars of steel, bent to the form of tuning forks (without shanks), the forks being of graduated lengths for the various musical notes. A sound-board is placed near the bottom of the case, having a bridge glued thereon, extending horizontally from end to end. Each fork is connected to the bridge on the sound-board by a piece of thin spring steel bent to the form of a semicircle, and having one end clamped to the fork by means of a pair of small plates secured by screws, whilst the other end is held by a small plate screwed to the bridge. The forks are additionally supported and kept in position at their nodes by resting in notches on a suitably-cushioned rail. The hammers rest on the central rail of the key frame, which is cushioned on its underside. The butts to which the hammers are connected are pivoted in the usual way, and fastened to the drop rail of the key frame. They are pressed down by spiral springs, which are also fastened to the drop rail. Hinged to, and depending from, regulating levers placed at the back end of each key are adjustable hoppers, which, acting on the underside of the butts, cause the hammers to strike down on the forks when the keys are pressed. The dampers act on one or both ends of each fork, and are connected by bent wires to hinged levers, which latter are supported in a position underneath the front of the keys by a wooden rail. This wooden rail also carries a guiding rail through which the wires connecting the dampers and keys pass. On the top of each wire is placed a cushioned regulating button. A hinged rail placed underneath the damper levers is actuated by another lever having its fulcrum on the inner front of the case, which brings the dampers under the control of the foot by means of a cord

passing through the front part of the case. The keys are in size and description exactly similar to those used in pianofortes.

The dulcitone in a solid mahogany case is nearly an exact duplicate of the one forwarded to Mr. Ruskin a short time ago by the present Mr. Walter Macfarlane, who most kindly desired to carry through his late uncle's intentions in this matter.

The dulcitone in ornamental case, with frets and extended end, mounted on stand, was made to a design kindly presented to me by Mr. G. A. Audsley, F.R.I.B.A., of Devon Nook, Chiswick, a gentleman who takes a friendly interest in my work, and to whom I am indebted for several valuable hints.

To Mr. Thomas Jowitt, of Sheffield, I am also indebted for valuable aid in ascertaining, by experiment, the most suitable character and quality of steel for my purpose.

Shown in illustration of this paper—

1. A sectional model of the instrument described in *Proceedings* for 1885.

2. Instrument in mahogany case—compass, 3 octaves.

3. Instrument in plain deal case—compass, $2\frac{1}{2}$ octaves.

4. Dulcitone as described to the Society.

5. Dulcitone in ornamental case, made to the design of Mr. G. A. Audsley.

XXV.—*On the application of Wind Power to the generation and storage of Electricity.* By PROFESSOR JAMES BLYTH, M.A., F.R.S.E.

[Read before the Society, 2nd May, 1888.]

IN common, I daresay, with many other persons, I have felt, for some time past, that the power of the wind was not sufficiently taken advantage of for the purpose of generating and storing electrical energy; and, in the course of last summer, I determined to make some experiments to test the point in a practical way. These consisted in the erection of a small windmill for supplying electric light by means of storage cells, to a small cottage in the village of Marykirk, Kincardineshire, where I usually spend my summer holiday. The mill was finished and working about the end of July, 1887.

The windmill is of the old English type, and is erected in the garden so as to have the best available exposure to the wind, although this is not so good as could be desired, and, indeed, in most places could easily be obtained. The tower consists of a wooden tripod firmly fixed in the ground and strongly braced together by bars of wood. The windshaft stands about 33 feet above ground, and carries four sail arms at right angles to each other, each being about 13 feet long. The canvas sails are attached to the arms, or whips, and are supported by sail bars in the usual way. By means of bevel wheels the windshaft gives motion to a long vertical shaft, from which, again, by bevel wheels, the motion is communicated to a horizontal axis which carries a fly-wheel, 10 feet in diameter, and which, of course, moves in a vertical plane. The dynamo, an old form of Birgin, is driven directly from the fly-wheel by means of a rope, and a workable speed is attained even when the windmill moves at a comparatively slow speed. The current from the dynamo is employed to charge 12 E.P.S. storage cells, which supply the incandescent lamps in the cottage. As yet I have only used, at one time, 10 eight-candle power 25-volt lamps, but I find that storage for more can be quite easily obtained. One day last summer, when a good breeze was blowing, I stored as much in half a day

as gave me light for four evenings, about three or four hours each time. As yet, however, I have not had time or opportunity to test fully the capabilities of my arrangement. For one thing, I require a more suitable dynamo and a much greater storage capacity, so as to take advantage of all the wind that blows; and when this is done I have no doubt whatever regarding the complete success of my experiment.

While charging, the current passes through a cut-out arrangement, which immediately disconnects the cells from the charging circuit when the dynamo runs below a certain speed. In this way the windmill can be allowed to run day and night, as it will only store when a certain speed is attained, and the cells are effectually prevented from discharging themselves through the dynamo, even should it stop.

I may mention that on several occasions I have used the stored electricity to drive a small turning lathe in my workshop, and that I have begun to make a light form of carriage to be driven by the same, so that I am in hope of having some day a drive by means of stored wind energy.

One day, during last Christmas holidays, there was a good breeze, and I tried, for curiosity, the experiment of direct lighting from the dynamo without the use of storage cells, the lamps being inserted as a shunt from the brushes. A fairly steady light was obtained from eight lamps, and the risk of burning them up was avoided by inserting two lamps of higher volts.

XXVI.—*On the Electrical Resistance of Slate and Marble and other Materials, with reference to their use in Electric Light Fittings.* By THOMAS SHIELDS, M.A.

[Read before the Society, 2nd May, 1888.]

THE subject of my remarks is one that not only possesses the theoretical interest which attaches to the publication of fresh information on any subject, but is also practically interesting in connection with its relation to electric lighting.

It would be difficult at the present moment to forecast the issue of the struggle between the partisans of the transformer system, and those of the accumulator system, of electrical distribution ; but if, as is not at all unlikely, the transformer system comes to be established, as for many purposes at once the most convenient and most economical system for the distribution of electricity, then it is obvious that the question of good insulation in the circuit will become one of even greater importance than it is at present. A system of insulation, for example, which was found quite satisfactory with a working potential of 100 volts, might speedily show signs of weakness and break down under a potential of 3000 volts.

The first point, of course, in the insulation of an electric circuit to be looked to is the insulation of the leads, but that forms no part of my subject. The next point is the insulation of any break or interruption in the leads, and it is here we find that faults by far most frequently occur and insulation breaks down. It is not, as a rule, in the insulation of the conductors themselves that faults occur, but in the insulation of the switches, fuses, cut-outs, electrical measuring instruments, &c., that are inserted in the circuit. On the authority of Mr. Addenbroke, at least 95 per cent. of the faults that occur have this origin. It is most important, therefore, to ensure that there is good insulation in these cases. The materials that have been chiefly used to secure this are slate and porcelain. The latter is open to the very serious objection of being easily cracked and broken. There are objections also to the use of slate, which will be considered later on. Its cheapness, however, together with its cleavage, which renders it capable of

being easily split into slabs, and the comparative ease with which it can be worked generally, have gone far to bring slate into favour for this purpose. The object of the investigation, the results of which I now set before you, was, in the first place, a determination, good enough for practical purposes, of its merits as an insulator compared with other materials which might conveniently be used for the same purpose.

As regards the methods of measurement, I adopted those which are in common use in cable-testing. When the resistance was comparatively low it was measured by means of a high-resistance mirror galvanometer by comparison with a known resistance. The connections of the apparatus used are shown in Fig. 1, Plate XI.

The resistance to be measured is denoted by R ; CO are two contact pieces of equal area; G is the galvanometer, and S an adjustable resistance arranged as a shunt between the terminals of the galvanometer; B is the battery, and K an ordinary make-and-break key. On depressing the key, the current which passes through R is measured by the galvanometer; R is then replaced by a known resistance, and the current which passes through it is measured. We thus get a comparison of the two resistances by comparing the currents which the same electro-motive force gives in the circuits of which they successively form part.

Let E denote the difference of potential between the terminals of the battery; R , the resistance to be measured; G , the resistance of the galvanometer; and d , the deflection obtained when the galvanometer is shunted with a resistance, S ; and let R_1 , S_1 , and d_1 denote the corresponding quantities when the unknown resistance, R , is replaced by the known resistance, R_1 .

Suppose that no shunt is used, then the current which passes through the galvanometer will be equal to $\frac{E}{R}$; but when the galvanometer is shunted with a resistance, S , the current will divide, and the part which passes through the galvanometer will be equal to $\frac{S}{S+G} \times \frac{E}{R}$. And since the deflection on the scale is proportional to the current which passes through the galvanometer, we get the equation—

$$\frac{S}{S+G} \times \frac{E}{R} = C \times d, \quad \dots \dots \dots (1)$$

where C is a constant quantity.

Similarly, when the known resistance is inserted in the circuit we have—

$$\frac{S_1}{S_1 + G} \times \frac{E}{R_1} = C \times d_1, \quad - \quad - \quad - \quad - \quad - \quad (2)$$

Hence, combining these two equations, we get—

$$\frac{\frac{S_1}{S_1 + G} \times \frac{E}{R_1}}{\frac{S}{S + G} \times \frac{E}{R}} = \frac{C \times d_1}{C \times d}, \quad - \quad - \quad - \quad - \quad - \quad (3)$$

Solving equation (3) for R, we have—

$$R = \frac{d_1 \times R_1 \times S \times (S_1 + G)}{d \times S_1 \times (S + G)}, \quad - \quad - \quad - \quad - \quad - \quad (4)$$

which gives us R in terms of known quantities, and we can thus proceed to calculate it. This value, R, is obviously directly proportional to the area of the contact pieces, and inversely proportional to the thickness of the material between them. The specific resistance, therefore, or resistance per cubic centimetre of the material, will be equal to $\frac{R \times A}{l}$, where A is equal to the area of contact in square centimetres, and *l*, the thickness in centimetres. Hence, if the resistances are given in ohms, the resistance between two opposite faces of a cubic centimetre of the material will be equal to $\frac{R \times A}{l}$ ohms.

Some of the materials tested, however, had too high a resistance to give a readable deflection on the galvanometer scale, and these had to be measured electro-statically by the quadrant electrometer. The method of joining up is shown in Fig. 2. A quadrant electrometer, Q, a standard condenser, K, and the resistance to be measured and contact pieces (which form a condenser), R, are all joined up in parallel with the charging condenser, C, so that one side of the apparatus, being joined to earth, is always at zero potential, while the other side is insulated perfectly in every respect except as regards R, the insulator whose resistance is to be measured. The insulated side is charged by depressing the key, *k*. Contact is made for half a minute, and the deflections on the electrometer scale are noted every half minute thereafter. We thus get the time-rate of the leakage through the insulator, R.

If C denotes the capacity of the standard condenser (the capacity of R , being very small compared with C , may be neglected); R , the resistance of the insulator R , and V and Q , the potential and quantity of charge: then

$$\begin{aligned}\frac{V}{R} \dot{t} &= \dot{Q} \quad \quad \quad (5) \\ &= \dot{C} V \\ &= C \dot{V}\end{aligned}$$

$$\therefore \dot{t} = C R \frac{dV}{V} \quad \quad \quad (6)$$

Integrating between the limits V_1, V , where V is the potential at time, $t = t$ say, and V_1 the potential at time, $t = 0$, we have

$$\begin{aligned}t &= C R \int_{V_1}^V \frac{dV}{V} \quad \quad \quad (7) \\ &= C R \log \frac{V}{V_1}\end{aligned}$$

$$\text{Hence } R = \frac{t}{C \log \frac{V}{V_1}} \quad \quad \quad (8)$$

The instrument being used idiostatically, the potential at any time is proportional to the square root of the deflection. If C is given in micro-farads, equation (8) will give R in megohms, and as before the specific resistance will be equal to $\frac{R A}{l}$ megohms.

The contact pieces used were of considerably smaller area than the slabs tested, so as to leave a margin of the insulator all round. The question of contact pieces gave a little trouble, but it was ultimately found most convenient to use sheets of tinfoil backed by a pad of cotton wool for low temperatures, and for high temperatures, platinum foil covered by a block of wood. To secure as good contact as possible, pressure was applied by means of heavy weights.

In Table I. there are shown the results of the first set of experiments. These measurements were made at the ordinary temperature of the Physical Laboratory of Glasgow University, and under ordinary atmospheric conditions generally, the only preparation which the various slabs received being a careful cleaning of their surfaces.

TABLE I.

MARKS.	MATERIAL.	SPECIFIC RESISTANCE.	
		In Megohms.	In C.G.S. Units.
I.	Slate, - - - -	14.84	1484×10^{12}
II.	Slate, - - - -	18.5	1850×10^{12}
III.	Serpentine, - - -	46.15	4615×10^{12}
IV.	Carboniferous limestone, -	265	2650×10^{14}
V.	Black marble, - - -	1027	1027×10^{12}
VI.	Fluorite, - - - -	4285	4285×10^{12}
VII.	White marble, - - -	7998	7998×10^{12}

The noticeable feature of these results is the comparatively low resistance of slate and the very high resistance of common white marble. The high insulation of the fluorite may have been partly due to the fact that the specimen tested was polished on both sides, but I have been unable as yet to verify this.

The same specimens were then baked for three hours over a sand-bath and again tested. As I have mentioned already, these preliminary experiments were for the purpose of arriving at a speedy determination good enough for practical purposes, and, consequently, no means were adopted to ascertain the temperature of the slabs when their resistance was measured. It was greater, however, than under ordinary conditions they would be subjected to in practice, and, inasmuch as each specimen was subject to exactly the same treatment, the figures in Table II. may be regarded as comparable to a great extent.

TABLE II.

MARKS.	MATERIAL.	SPECIFIC RESISTANCE.	
		Megohms.	C.G.S. Units.
I.	Slate, - - - -	8.7	87×10^{14}
III.	Serpentine, - - -	37.0	37×10^{12}
V.	Black Marble, - - -	20,000.0	20×10^{12}
VII.	White Marble, - - -	19,000.0	19×10^{12}

The various materials were next subjected to a process of paraffining. They were suspended in boiling paraffin for about six hours in such a way that, while the under surface was immersed in the paraffin, the bulk of the slab was exposed to the air. By this arrangement it was hoped that the air and moisture in the various slabs would be completely expelled by the paraffin. The success of this process varied considerably with different materials, and this point is particularly interesting in view of some remarks made recently relative to this subject at a meeting of the Society of Telegraph Engineers and Electricians. It was in the discussion a few months ago on Mr. Cockburn's paper on "Safety Fuses," in which Mr. Crompton stated that slate when soaked in paraffin made an almost perfect insulator. Instead of this I found that slate scarcely absorbed paraffin at all: the paraffin, indeed, owing to surface action, soon overspread the slate, but it did not penetrate into the material. And so, indeed, it was found when the paraffin was removed from the surface and the slate again tested, that the resistance remained the same as it was when in the normal condition. Consequently, it was on the thin coating of paraffin that Mr. Crompton had to depend for his insulation, and not on the slate itself. It was found, moreover, that serpentine absorbed the paraffin only to a very slight extent, but that white marble readily absorbed it. In the latter case there was another curious and also practically important effect of the paraffining process, which had a hardening effect on the marble, rendering it much less easily breakable. The effects of the paraffin on the insulating qualities of the various materials are shown in Table III.

TABLE III.

Marks.	Material.	SPECIFIC RESISTANCE.	
		Megohms.	C.G.S. Units.
I.	Slate, - -	14	14×10^{13}
III.	Serpentine, -	83	83×10^{13}
V.	Black marble, -	8,000	80×10^{17}
VII.	White marble, -	5,000,000	50×10^{20}

All these figures point to the superiority of marble as an insulator, and there is no reason against its occupying the place which slate at present holds in electric light fittings, and almost every reason in its favour.*

Although valuable from a practical point of view, the figures which I have given do not, however, represent the true insulating value of the materials, inasmuch as the measurements were made in the presence of some moisture at least, or else of paraffin. My next object, therefore, was to get rid of moisture entirely and secure a measurement which would represent the specific resistance of the materials themselves. The arrangements made to effect this are shown in Fig. 3, which sufficiently explains itself. Arranged as before, the insulator and contact pieces are enclosed in a tin-plate box, which, in its turn, is enclosed in a sand-bath. The conductor from one of the contact pieces is led through a wide glass tube to the insulated quadrants and the other conductor is led to earth. The arrangements for testing are the same as those shown in Fig. 2. The apparatus in Fig. 3 was heated up to about 200° C. and kept at that temperature for some hours. All the moisture expelled from the insulator was absorbed by strong sulphuric acid placed in a vessel in the inner box. As the insulator was allowed to cool, readings were taken at intervals, and the specific resistance at various temperatures deduced. The curves in Fig. 4 are plotted from the values obtained for slate and marble at various temperatures, and may, I think, be regarded as giving the specific resistance at those temperatures of the materials themselves free from moisture.

Finally, it may be interesting to observe how these materials compare as insulators with glass. Table IV. gives the specific resistance at 100° C. of slate and marble and some kinds of glass, varying in density and percentage composition. The figures for glass in this Table are taken from Messrs. T. Gray and J. J. Dobbie's paper "On the Electrical Qualities of Glass," in the *Proceedings of the Royal Society* for 1884.

* Since this paper was read the President of the Vienna Society of Electricians, who officially inspected the underground system in connection with the lighting of the Burg Theatre, Vienna, recently completed, has stated that the only defective insulation in the system existed in the slate supports of the cut-outs, and of the other apparatus of this kind.

TABLE IV.

Material.	Density.	PERCENTAGE COMPOSITION.		Specific resistance at a temp. of 1000° C. in absolute units.
		Sio ₂ .	PbO.	
Glass, - -	3·141	47·5	40·6	84×10^{21}
„ - -	3·145	55·7	37·1	47×10^{21}
„ - -	2·854	62·7	20·6	$5·34 \times 10^{21}$
„ - -	2·811	62·3	19·9	$4·53 \times 10^{21}$
White Marble,	...	...	...	$2·15 \times 10^{21}$
Slate, - -	...	...	...	$0·84 \times 10^{21}$

ON THE ELECTRICAL RESISTANCE OF SLATE AND MARBLE.

Fig. 2.

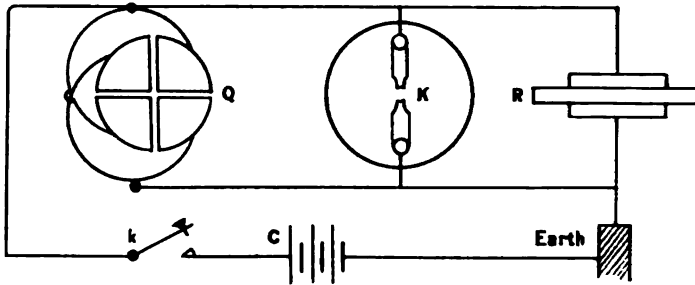
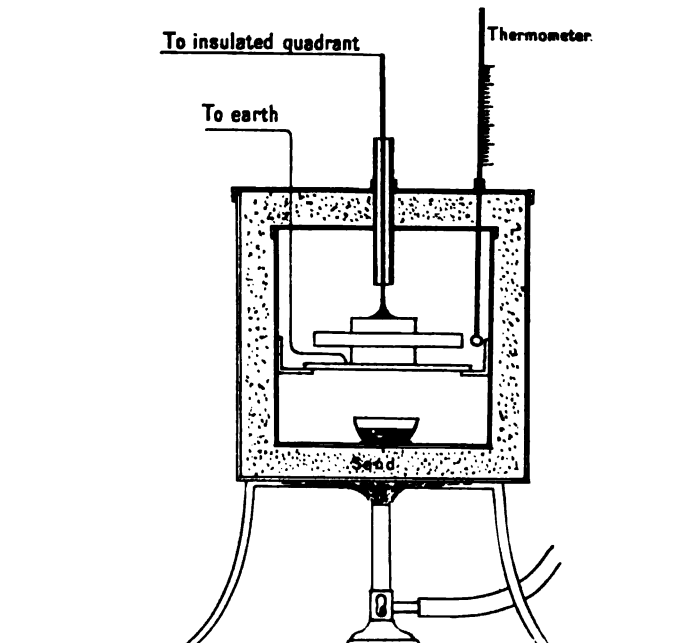


Fig. 3.



ON THE ELECTRICAL RESISTANCE OF SLATE AND MARBLE.

Fig. 1.

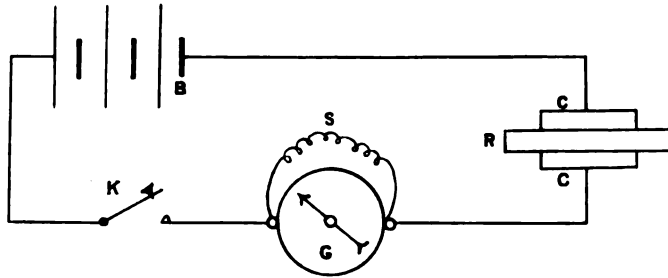
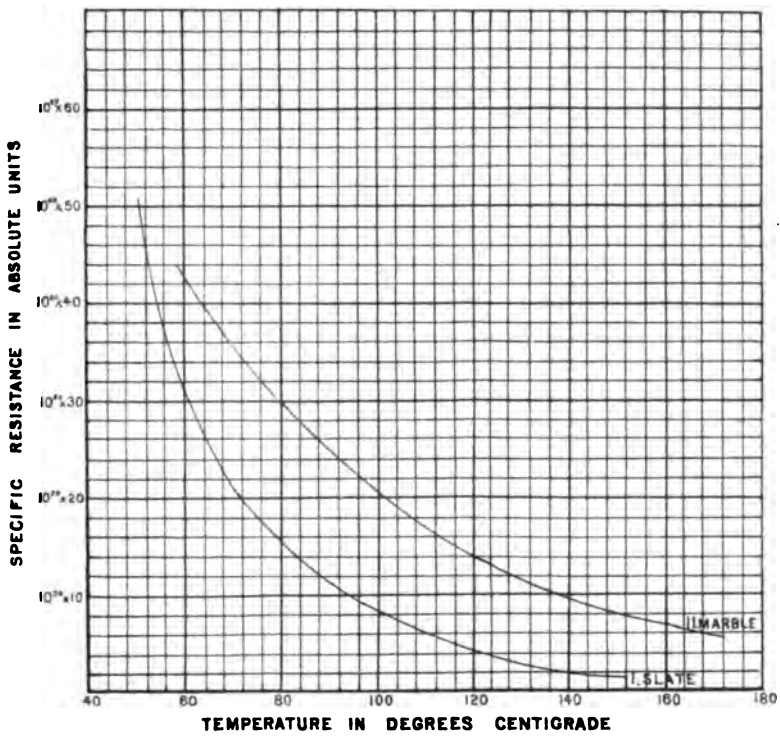


Fig. 4



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REPORT OF THE SOCIETY'S REPRESENTATIVE AT THE GLASGOW AND
WEST OF SCOTLAND TECHNICAL COLLEGE.

[Read before the Society, 2nd May, 1888.]

JOHN MAYER, Esq.

2nd May, 1888.

DEAR SIR,—For the information of the President, Council, and Members of the Philosophical Society, I beg to report that, as the representative of the Society, I have attended thirty-three meetings of the Governors of the Glasgow and West of Scotland Technical College.

The amalgamation of old and rival institutions has necessarily been a work of time and labour, but I am now glad to report that my able colleagues are working in a most harmonious way for the interests of the College, and that much excellent work has been done in extending the scope and number of the classes, both in the day departments and evening class departments of the College proper, and in the School attached to the College known as "Allan Glen's."

In regard to the latter, extensive additions have been arranged for the Buildings, and also much-needed repairs and additions of apparatus have been made both in the Bath Street and the Andersonian Buildings.

The attendance at the classes during the present session has been quite as large as anticipated by the Governors.

It is hoped that the generous support of the public will be forthcoming in providing funds for improving the position of the College as regards its buildings, which are far behind those of other towns in appearance and accommodation for the students, a finer body of whom scarcely exists in the United Kingdom, measured by their success at examinations.

Finally, I have to draw attention to the new Calendar of the College which will shortly be issued, and which embodies the arrangements for the new session and thereafter, the details of which, especially as regards the various curricula for diplomas, have had a deal of our anxious consideration.

Yours faithfully,

J. J. COLEMAN.

REPORT OF DELEGATE TO THE BRITISH ASSOCIATION—
MANCHESTER, 1887.

[Communicated to the Society, 2nd May, 1888.]

Last Session the Council of this Society appointed its former President, Dr. Muirhead, its delegate to attend the Meeting of the British Association at Manchester. Dr. Muirhead was not in his usual health, and he desired me to act as delegate for him. This I did, and I have now to make a short report of the chief business at the meetings of the delegates of the Corresponding Societies of the British Association. The official report of the proceedings may be seen in the "Report of the British Association" for the year.

These annual meetings of delegates from scientific societies were arranged three years ago for the purpose of securing more co-operation amongst local societies than had existed previously, and of directing their work to a number of desirable subjects, which could be wrought out best under a common plan.

The subjects referred to at the meetings of delegates I shall arrange under the different sections to which they belong. There were two meetings and thirty-two delegates, of whom seven were from Scotch societies.

I. PHYSICS.

Temperature Variation in Lakes, Rivers, and Estuaries.—Societies situated in the neighbourhood of these might do useful work by getting some of their members to take daily or weekly observations of temperature. Rules are to be drawn up for this purpose, and observers willing to undertake the work are desired to communicate with Dr. J. Murray, Secretary of this Committee, "Challenger" Office, Queen Street, Edinburgh.

Earth Tremors.—Professor Lebour said that Corresponding Societies might do good work by establishing a great network of seismoscopes and seismographs. A seismoscope could be bought for £2, and a seismograph for £25. The Secretary of this Committee, Professor Lebour, College of Physical Science, Newcastle-

on-Tyne, said he would be glad to communicate with anyone interested in the subject.

II. GEOLOGY.

Underground Water.—Information is required as to “depth of wells, sections passed through, the height at which water stands before and after pumping, daily records of height, and chemical analysis of water.” Circular forms of inquiry can be obtained from C. E. de Rance, 28 Jermyn Street, London, S.W.

Erratic Blocks.—Size, character, and position should be marked on one-inch Ordnance Map. Circular forms of inquiry of Rev. Dr. H. W. Crosskey, 117 Gough Road, Edgbaston, Birmingham.

Sea Coasts Erosion.—Particulars and forms of inquiry are supplied by William Topley, 28 Jermyn Street, London, S.W.

III. BIOLOGY.

Life-Histories of Plants.—A letter was read from Professor Bayley Balfour, in which it was urged that much good scientific work might be done by local societies by encouraging their members to “study the life-histories of indigenous plants in their entirety, that is to say, from the stage of embryo in the seed up to the production of fruit and seed again.” As examples of contributions of such a kind, those of Lubbock, Hermann, Müller, Kerner, and Ogle were mentioned, and special attention was directed to the work done by Wydler and Irmisch on the native plants of Germany.

Provincial Museums.—The Committee had been engaged collecting particulars of museums out of London, and they intend to visit all the local museums of Germany, France, and America.

IV. ANTHROPOLOGY.

Prehistoric Remains.—Good service could be rendered by inducing proprietors of such remains to communicate with General Pitt-Rivers, the Inspector of Ancient Monuments, 4 Grosvenor Gardens, London, S.W., with the object of placing these remains under government protection. This, the Chairman said, applied particularly to Scotland. The recommendations General Pitt-Rivers wished to make were these:—Local societies should (1) report to him what monuments in their district they think worthy of being put under the Act; (2) they should send him the names

and addresses of the owners; (3) they should communicate with the owners, and, if possible, obtain their consent to have the monuments placed under the Ancient Monuments Act; and (4) they should report to him any damage being done to such monuments, or contemplated. With such assistance he thinks much more rapid progress may be made.

W. C. CRAWFORD.

REPORTS OF SECTIONS.

SESSION 1887-88.

[Received at Meeting of Society on 2nd May, 1888.]

1. REPORT OF THE ARCHITECTURAL SECTION.

During the Session eight Meetings have been held, at which nine papers have been read. The following is a list of the papers read at the Meetings :—

Monday, November 14, 1887.—Opening Meeting, when Mr. James Thomson, architect, F.R.I.B.A., President of Section, gave his Address, subject, “Remarks on the Architecture of Glasgow during the past Fifty Years.”

Monday, November 28, 1887.—Mr. Francis H. Newberry, Glasgow School of Art, read a paper on “The Training of Architectural Students.”

Monday, December 12, 1888.—Mr. T. L. Watson read a paper on “Fire Prevention and exits from Public Buildings.”

Monday, January 16, 1888.—Mr. George H. Laird, wright, read a paper on “Wright Work ;” and Mr. Alexander Brown, plumber, read a paper on “Plumber Work, Past and Present.”

Monday, January 30, 1888.—Mr. Thomas Gildard, architect, read a paper on “Greek Thomson.”

Monday, February 13, 1888.—Mr. Robert Brydall, St. George’s Art School, read a paper on “Early Sculpture in Scotland.”

Monday, February 27, 1888.—Mr. Harry W. Chubb, of London, read a paper on “Ancient, Mediæval, and Modern Locks and Keys.”

Monday, March 12, 1888.—Mr. Andrew Black read a paper on “Iron Construction as adapted to Building Purposes.”

The thanks of the Section are due to all those gentlemen.

During the Session 10 Associates joined the Section.

The Annual Business Meeting was held on Monday, March 12, when the following gentlemen were elected to office:—

President—Mr. James Thomson, architect.

Vice-Presidents—Mr. Thomas Gildard and Mr. R. A. M'Gilvray.

Treasurer—Mr. James Howatt.

Secretary—Mr. A. Lindsay Miller, architect.

Members of Council—Messrs. James Sellars, architect; David Thomson, architect; T. L. Watson, architect; David MacBean, architect; James Chalmers, architect; William Howatt, measurer, Alexander Muir, builder; William Gilfillan, marble cutter; Andrew Black, smith; William Cairns, plumber.

(Signed) A. LINDSAY MILLER,
Hon. Secy. of Section,
121 WEST REGENT STREET.

2. REPORT OF THE GEOGRAPHICAL AND ETHNOLOGICAL SECTION.

Two papers from the Section were read before the Society during the Session. The first was on "Burmah," by Mr. A. Colquhoun. This was read at a joint Meeting of the Society and the Chamber of Commerce, held in the Hall of the Society, on the evening of Friday, 11th November. It was illustrated by a number of lime-light views. The second, on "The River Plate System," by Mr. John Galloway, was read at the Society's Meeting on 7th March, and is printed in the *Proceedings*. In addition to these, two Meetings were held under the arrangement for holding joint Meetings with the Glasgow Branch of the Scottish Geographical Society, at which the following papers were read:—1st, "The Antarctic Regions," by Mr. A. Silva White, on 18th January; 2nd, "Attempts to reach the Owen Stanley Peak," by Mr. H. O. Forbes, on 3rd April. Mr. Forbes' lecture was given in the Reception Room, Queen's Rooms, and was illustrated by lime-light views of New Guinea, and by a large collection of curios and birds.

Office-Bearers for 1887-88.

President—W. G. Blackie, Ph.D., LL.D., F.R.G.S.

Vice-Presidents — James Stevenson, F.R.G.S.; Sir Michael Connal, Thomas Muir, M.A., LL.D., F.R.S.E.

Secretary and Treasurer—G. A. Turner, M.D., C.M.

Members of Council.—Mr. Jas. Grierson, Mr. Maxwell Hannay, Mr. Wm. Ker, Mr. Jacques Van Raalte, Mr. Alex. Scott, Mr. W. Renny Watson, Mr. Robt. Blyth, C.A.; Mr. George Miller, Mr. Jas. Christie, A.M., M.D.; Mr. William Ewing, Mr. Nathaniel Dunlop, Mr. Robert Gow.

(Signed) GEO. A. TURNER, M.D.,
 Secretary.

3. REPORT OF THE BIOLOGICAL SECTION.

The Section held no Meetings of its own during the Session.

Professor M'Kendrick read a paper before the Society on "The Modern Cell Theory," and gave demonstrations of (1) a Spectropolarimeter; (2) a Gas Pump for extracting Air from the Blood; (3) a Centrifugal Apparatus for separating Blood Corpuscles; (4) an Electro-myographion.

Mr. Maylard gave a demonstration on "Bacteriology."

(Signed) JOHN YULE MACKAY, M.D.,
 Secretary.

4. REPORT OF THE MATHEMATICAL AND PHYSICAL SECTION.

At the Annual General Meeting of the Society, held on the 16th November, 1887, the following Office-Bearers were appointed to the Mathematical and Physical Section:—

President—Sir William Thomson, LL.D., F.R.S., &c.

Vice-Presidents—Thomas Muir, M.A., LL.D.; and Professor Robert Grant, LL.D., F.R.S.

Secretary and Treasurer—Mr. Thomas Gray, B.Sc., F.R.S.E.

Members of Council—Mr. Peter Alexander, M.A.; Professor James Blyth, M.A.; Mr. James T. Bottomley, M.A.; Mr. Henry Dyer, M.A., B.Sc.; Professor William Jack, LL.D.; Professor Andrew Jamieson, F.R.S.E.; Professor James Thomson, F.R.S.; Mr. Magnus Maclean, M.A.; Mr. James Wood, M.A.

The Section has contributed three papers to the Society during the Session, and the following new Associates have been elected:—

Mr. J. H. Gray, Mr. W. Leckie, Mr. Andrew W. Meikle, Mr. James Erskine Murray, Mr. Thomas Shields, Mr. Malcolm Sutherland.

(Signed) THOMAS GRAY,
Secretary,

PHYSICAL LABORATORY, UNIVERSITY OF GLASGOW.

5. REPORT OF THE CHEMICAL SECTION.

The Associates have during the past Session been invited by post-card to the periodical Meetings of the Glasgow and West of Scotland Branch of the Society of Chemical Industry. No papers have been directly contributed to the Section during the Session.

The fact of the existence of the above-named Society, together with the establishment some time ago of a large Chemical Society, similar in its aims to our Section, in connection with one of the principal educational institutions of the City, accounts for the absence of progress in our Chemical Section.

There are ten Associates on the roll, one of whom during the Session joined the Membership of the Philosophical Society.

(Signed) JOHN TATLOCK,
Secretary.

6. REPORT OF THE SANITARY AND SOCIAL ECONOMY SECTION.

A Meeting of the Section was held on 16th November, 1887, at which the following Office-Bearers were elected:—

President—Eben. Duncan, M.D., 4 Royal Crescent, Crosshill.

Vice-Presidents—James Christie, M.D., 2 Great Kelvin Terrace;
and John Glaister, M.D., 4 Grafton Place.

Members of Council—Messrs. Alex. Frew, 175 Hope Street;
Neil Carmichael, M.D., 29 South Cumberland Street; W. R. W.
Smith, 6 South Hanover Street; John Young, 234 Parliamentary
Road; James Chalmers, 101 St. Vincent Street; Peter Fyfe, 1
Montrose Street; Walter Arrol, 16 Dixon Street; Alex. Scott,
2 Lawrence Place; W. P. Buchan, 21 Renfrew Street; J. C.
Burns, 30 Jamaica Street; John Honeyman, 140 Bath Street;
and H. K. Bromhead, 245 St. Vincent Street.

It was agreed to recommend that papers by the following gentlemen be read before the Society during the Session, viz.:—
(1) Paper by Mr. John Honeyman; (2) Paper by Mr. Peter Fyfe.
Mr. Honeyman was unfortunately unable to complete his paper in time for this Session. Mr. Fyfe read his paper before the Society on 11th April, 1888, the subject being "Important Points in the Sanitary Work of a great City."

The Section has been occupied during the latter part of the Session with the Memorial to be presented to the Secretary for Scotland on (1) the Amendment of the Burials Act; (2) Consideration of other means than the present for the disposal of our dead.

(Signed) W. R. M. CHURCH,
Secretary,
75 ST. GEORGE'S PLACE.

7. REPORT OF THE ECONOMIC SCIENCE SECTION.

The Economic Science Section has held eleven Meetings during the Session, and has sent one communication to be read before the Philosophical Society. Several Associates have retired and several have joined during the Session, the total number being now 61, or three more than at the close of last Session. One Associate has become a Member of the Society, and some of the Members who have joined the Society during the present Session have done so on account of their interest in the work of this Section.

The following is a statement of the work accomplished during the Session:—

Monday, November 7, 1887.—Paper on “Railway Rates,” read by Mr. Mark Davidson, M.A., LL.B., advocate.

Wednesday, November 11, 1887.—Paper on “Factory Industry and Socialism,” read by Mr. Wm. Smart, M.A., before the Philosophical Society.

Monday, November 21, 1887.—Meeting for the discussion of Mr. Smart’s paper.

Monday, December 5, 1887.—Paper on “Co-operative Production and Profit Sharing,” by Mr. James Mavor.

Thursday, January 12, 1888.—Paper on “Free and Fair Trade,” by Mr. Stephen Mason, M.P.

Monday, January 23, 1888.—Paper on “Godin’s Familistère,” read by Mr. J. Murray Templeton.

Monday, February 6, 1888.—Paper on “American Currency,” read by Mr. And. S. McClelland.

Monday, February 20, 1888.—Paper on “The Constitution and Course of the Money Market,” read by Mr. Charles Gairdner, President of the Section.

Monday, March 5, 1888.—Paper on “Emigration,” read by Mr. Walter W. Blackie, B.Sc.

Monday, March 19, 1888.—Paper on “Preventible Bankruptcies,” by Mr. John Mann, jun., M.A., C.A.

Thursday, April 5, 1888.—Paper on “Some of the Social and Economic Aspects of the Welsh Land Question,” read by Professor H. Jones, M.A., of University College, Bangor.

Three new Members have been added to the Council, namely:—Mr. George Barclay, Mr. Chas. E. Beckett, M.A., LL.B.; Mr. James Marr.

(Signed) WALTER W. BLACKIE,
Hon. Secy. of Section.

MEMOIR OF MR. DAVID SANDEMAN.*

DAVID SANDEMAN was born at Edinburgh in 1814. After receiving his education there he went to London, and spent several years in business houses in the Metropolis before founding the Glasgow firm with which his name was so long and so honourably identified. During the greater part of his life in this city he took a deep interest in the cause of Technical Education. The frequent visits he paid to France and Germany enabled him to obtain a clear insight into the principles on which this important branch of education is conducted on the Continent, and to appreciate the advantages it confers on foreign manufacturers. It was the earnest desire he felt for the enjoyment of similar advantages in our own country that led him to become a warm advocate and promoter of the movement inaugurated in Glasgow in 1871 for the establishment of a Technical College. He joined the first committee appointed for this purpose, under the convenership of Mr. Walter Montgomerie Neilson, and became one of its most active members. Without dwelling at length on the history of the labours of that committee, the fact may be recalled that it aimed at the creation of an institution which should not only provide technical education in Glasgow, but should also send lecturers for the same purpose to the suburban districts, and even to such places as Greenock, Paisley, Dumbarton, Airdrie, Coatbridge, &c. An industrial museum, as a valuable aid and stimulus to the technical arts and manufactures, also formed part of the committee's programme. At first it was thought that the old Glasgow Mechanics' Institute buildings might be utilized as the centre from which the initiative operations of the Technical College could be conveniently carried out. It being found, however, that no satisfactory arrangement could be made with the managers of that institution, the committee drew up a more matured proposal for an entirely independent building as a Technical College. The failure of such a scheme is too well known: it was wrecked on the money question.

The committee fixed the sum to be raised at £50,000, and appointed Mr. Sandeman to act as treasurer of the fund. He threw

* Prepared at request of Council.

himself heartily into the work, but, though he obtained the promise of large sums from many who were foremost in the cause, and subscribed liberally himself, the fund did not exceed £12,000. Some members of the committee became discouraged at the want of success, and talked of abandoning the project altogether; but Mr. Sandeman was determined that it should not fall to the ground. He argued in favour of at least one branch of the Technical College, the Weaving School, being organised; and, finding able supporters in Mr. Montgomerie Neilson and others, he was authorised by the committee to call up a portion of the subscriptions. Even this was found no easy task, but after a prolonged struggle, in which Mr. Sandeman obtained able assistance from Mr. Frame, the secretary of the College, a fund of £4,500 was secured. Early in 1874 Mr. Sandeman and Mr. Templeton were appointed to look out for a site for the Weaving School, and, with the approval of the trustees, a small piece of ground was purchased in Well Street, Calton, a locality considered the most suitable in Glasgow on account of the majority of the weaving factories being situated in the neighbourhood. A weaving shed, lecture rooms, and offices were erected, and the school was opened in September, 1877, by Sir James Bain, then Lord Provost of Glasgow. It was supposed that probably about twenty pupils might attend the school, but in the very first session this number was more than doubled. Since then the average number of pupils has been sixty. Manufacturers have borne testimony to the great advantages of the practical instruction given at the school by making a certificate of attendance a recommendation for entering their employment. It is also satisfactory to know that the site, the building, and its contents are almost entirely free from debt. For all these results great credit must be given to many of our leading citizens, as well as to the Worshipful Company of Clothworkers, London. Beyond all question, however, the prosperity of the institution is mainly due to the energy and indomitable perseverance which Mr. Sandeman threw into the undertaking.

In other educational establishments of our city Mr. Sandeman took a very warm and active interest. He was for many years a Director of Anderson's College. He was also President of the Mechanics' Institute from 1873 to 1878, and continued to be a Director until 1883 not only of the Mechanics' Institute, until it was reconstructed in 1880, but also of the College of Science and Arts. Besides taking a share in the management of these

institutions, he subscribed most heartily every year for prizes to be distributed amongst the most deserving pupils, and in 1882 he presented a very handsome gold medal for competition amongst the engineering students. Mr. Sandeman long advocated the amalgamation of the various technical schools of the city under one governing body, and had the gratification some time before his death of witnessing the fruition of his efforts in this direction by the establishment of the Glasgow and West of Scotland Technical College, embracing Anderson's College, the College of Science and Arts, and Allan Glen's School. The Weaving School is not yet included in the Glasgow and West of Scotland Technical College, although provision is made in the Scheme for this being done. In the meantime, however, the instruction given in the Weaving School forms a part of the curriculum in "Textile Industries" in the College.

In many of the industrial, benevolent, and literary institutions of Glasgow Mr. Sandeman likewise took a leading part. He was a member of the Chamber of Commerce, and for many years one of its directors. At the City Parochial Board he long had a seat. He was connected with the old Glasgow Public Library, and became one of the directors on the amalgamation, in 1871, of the library with Stirling's. In 1875 he was elected treasurer of Stirling's Library, and remained in that office until his death. Mr. Sandeman was also a member of the Archæological Society, which he joined in 1879, and acted as a member of the Council from 1880 to 1886. In the pursuit of geology he took a lively interest. Becoming a life member of the Geological Society in 1861, he afterwards served on the Council, and acted at one time as its vice-president. Though he did not contribute any original papers to the Geological Society, he had more than a superficial knowledge of the subject; and all visitors to Woodlands will remember the keen delight with which he was wont to exhibit his own admirable collection of fossils, mostly derived from the West of Scotland.

Mr. Sandeman became a member of the Philosophical Society in 1870, and took a very active interest in its work, especially in so far as that was connected with technical education. On this subject he read several papers before the Society, which were very fully discussed at the time, and did much to rouse public opinion as to the necessity for steps being taken to keep the industries of the country on a level with those of our Continental rivals.

In the county of Dumbarton, where he resided, Mr. Sandeman will also long be remembered. He held office as one of the Justices of the Peace for the county, and for some years reigned over the burgh of Kirkintilloch as Provost, being instrumental at that time in introducing an abundant water supply.

In private as in public life Mr. Sandeman had troops of friends. A man of much culture, and of a most amiable and genial disposition, he enjoyed the respect, it might almost be said the love, of all who had the pleasure of his acquaintance. He died at his residence, Woodlands, Lenzie, on the 16th day of December, 1887.

HENRY DYER.

MINUTES OF SESSION.

2nd November, 1887.

The Philosophical Society of Glasgow held its First Meeting for Session 1887-88 on the evening of Wednesday, 2nd November, 1887, at eight o'clock, in the Society's Rooms, 207 Bath Street—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of Meetings held on 27th April and 4th May, 1887, which had been printed in Vol. XVIII. of the Society's *Proceedings*, now in the hands of the Members, were held as read, were approved of, and signed by the Chairman.*

2. The President delivered his Inaugural Address, the subject of which was "Some Sociological Aspects of Sanitation." At the close, he was awarded a hearty vote of thanks, on the motion of Sir James Bain, seconded by Mr. James Cleland Burns.

3. Mr. James Thyne M'Callum, of the Great Western Nurseries, read a paper on "Recent Progress in Horticulture," which was illustrated by some Typical Plants. He received the thanks of the Society for his paper. A discussion ensued, in which the speakers were—The President, Mr. M'Lellan (Superintendent of the City Parks), Mr. J. D. Campbell, Mr. J. C. Burns, Dr. Thomas Muir, and Mr. W. R. W. Smith.

4. On the motion of the President, Mr. Robert Blyth, C.A., and Mr. James Muir, C.A., were appointed to audit the Treasurer's Accounts for the year 1886-87.

5. The President announced that the following gentlemen, who had been proposed as Candidates, had been duly elected Members of the Society:—Mr. William E. Kay, Printworks, Thornliebank; Mr. J. E. Ackroyd, engineer, 237 Gairbraid Street, Maryhill; Mr. Robert Duncan, shipbuilder, Port-Glasgow; Dr. David Pride, Townhead House, Neilston; Mr. William Mackinlay, 4 Bothwell Terrace, Hillhead; Mr. Alexander M. Graham, iron

* See pages 429-431, Vol. XVIII.

and coal master, 20 Dixon Street; Mr. Richard J. Wilson, head master, St. George's Road Public School; Mr. D. M. Alexander, writer, 8 Royal Crescent, Crosshill; Mr. Robert Anderson, jun., printer, 22 Ann Street.

16th November, 1887.

The Annual General Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the evening of Wednesday, 16th November, 1887, at eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Opening Meeting of the Session, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. William E. Kay, Mr. J. E. Ackroyd, Mr. Robert Duncan, Dr. David Pride, Mr. William MacKinlay, Mr. Alexander M. Graham, Mr. Richard J. Wilson, Mr. D. M. Alexander, and Mr. Robert Anderson, jun., were admitted to the Membership of the Society.

3. The Annual Report by the Council on the state of the Society, having been printed in the Billet convening the Meeting, was held as read, and was unanimously adopted, and ordered to be printed in the *Proceedings*. The following is the Report:—

REPORT ON THE STATE OF THE SOCIETY BY THE COUNCIL
FOR SESSION 1886-87.

I. *Meetings*.—During the Session, which opened on 3rd November, 1886, and closed on 4th May, 1887, there were fifteen meetings held, one being an extra meeting, which took place in the Natural Philosophy Class-Room at the University, on the invitation of Sir William Thomson. At these meetings papers were read and verbal communications made to the number of thirty-six, of which twenty-nine are published in the new volume of the *Proceedings*. Two joint-meetings with the Scottish Geographical Society were also held, at which two papers were read.

II. *Membership*.—The number of Ordinary Members on the Roll at the beginning of Session 1886-87 was 662; during the Session 41 new Members

were elected, and one name was reinstated from the "Suspense List," making 704; of these 29 have resigned, 13 have died, 13 have left Glasgow and their names have been placed on the Suspense List, and 7 have been struck off the Roll for non-payment of subscriptions; leaving on the Roll at the beginning of the present Session 642 Members, being a decrease of 20. Of the 41 New Members, 6 became Life Members; and 5 Ordinary Members also paid the composition of Life Members during the Session. There are now 90 Life Members. No vacancies exist in the list of Honorary Members. There are at present 20 Honorary Members, of whom 7 are Continental, 5 are American or Colonial, and 8 are British. The number of Corresponding Members is 10. The Membership of the Society then is as follows:—Honorary Members, 20; Corresponding Members, 10; Ordinary Members, 642; or a total of 672.

III. *Sections*.—(1) Eight meetings of the *Architectural Section* were held during the Session, at which twelve papers were read. One of these, dealing with "Some Minor Rights of Land-Ownership," by Mr. Archibald Ferguson, writer, appears in the *Proceedings*. The Council are much pleased to observe the continued activity and usefulness of this Section, the success of which is largely due to the energy and business tact of Mr. A. Lindsay Miller, the Honorary Secretary.

(2) In regard to the *Chemical Section*, it is satisfactory to report that before the beginning of the Session the Council of the Section were able to conclude such arrangements as would admit of the Associates being made welcome to attend the meetings of the Scottish Branch of the Society of Chemical Industry, which are held in the Rooms of the Philosophical Society. It is also satisfactory to know that at least five communications on Chemical Science were made at the ordinary meetings of the Society during the Session.

(3) The *Sanitary and Social Economy Section* provided two papers which were read before the parent Society, one of them being the President's Address. They are both published in the *Proceedings*.

(4) No separate meetings of the *Geographical and Ethnological Section* were held during the Session, but through its means three papers, in addition to those already referred to, were read at General Meetings of the Society. These all appear in the *Proceedings*.

(5) Through the *Biological Section* five communications were made to the Society at the ordinary meetings. They are all published in the *Proceedings*.

(6) Five communications were made to the General Meetings of the Society through the agency of the *Mathematical and Physical Section*; and, in addition, two separate meetings of the Section were held, at which four short papers were read. Six of these papers appear in the *Proceedings*.

(7) The Council are much pleased to be able to report that a movement, which was commenced early in the course of the Session, has resulted in the formation of the *Economic Science Section*, which has already shown great activity. This Section had enrolled fifty-six Associates before the close of the Session; and, in addition, it was influential in providing a number of new members to the Society. The Section was inaugurated by an address from the President, Mr. Charles Gairdner, which is published in the *Proceedings*. It was delivered at one of the Society's General Meetings, but the Section also held six separate meetings. Special note should be made of the valuable services rendered to this Section by Mr. Gairdner, Mr. William Smart, one of the Vice-Presidents, and Mr. Walter W. Blackie, the Secretary of the Section.

IV. *Proceedings*.—Volume XVIII. of the Society's *Proceedings*, which was recently issued, is of such a character as to warrant the Council in congratulating the members generally upon its appearance. It contains thirty-four communications bearing upon a great variety of scientific and technological subjects, and several of them will doubtless contribute very materially to enable the Society to maintain a high position in the ranks of the Scientific Societies of the United Kingdom. These papers are illustrated by means of twenty-seven figures distributed through the text, and by fifteen plates, five of which are coloured.

V. *The Graham Lecture*.—A prominent item of the Society's work during the Session was the delivery of the third Triennial "Graham" Lecture, by Dr. T. E. Thorpe, F.R.S., who was formerly an active and esteemed member of the Philosophical Society of Glasgow. His address (which appears in the *Proceedings*) is an eloquent sketch of a portion of the work done in Chemical Physics by Professor Graham, the late Master of the Mint, and a former Vice-President of this Society. This Triennial Lecture is delivered under the auspices of the Society, and paid for out of the Graham Medal and Lecture Fund, of which the Society is the Trustee. It is hoped that in subsequent years other eminent cultivators of science may be brought to Glasgow to discharge a duty similar to that performed by Professor Thorpe.

VI. *Glasgow and West of Scotland Technical College*.—In this Report notice should be taken of the fact that, in the creation of the Glasgow and West of Scotland Technical College, due regard has been had to the prominent and influential position of the Philosophical Society. Along with various other public bodies in Glasgow, the Society was empowered to elect one of the Governors of the College, and the Council are glad to know that in selecting Mr. J. J. Coleman, F.R.S.E., as the Society's representative, they made an excellent choice.

VII. *Representative to the Scottish Meteorological Society*.—In the course of the past Session the Council were requested by the Scottish Meteorological Society to appoint a representative to assist in the

management of the Ben Nevis Observatory, in conjunction with representatives of the Royal Societies of London and Edinburgh. The recognition of the status of the Society, both in this instance and in the Governorship of the Technical College, was mainly due to the exertions of Dr. Henry Muirhead, who represents the Society as one of the *ex-officio* Members of Council of the Meteorological Society.

VIII. *Index to Proceedings*.—The Council have pleasure in intimating that, in accordance with a strongly-expressed desire, a General Index to the Society's *Proceedings* is now in course of preparation. It is intended to make it embrace a series of twenty volumes of *Proceedings*, two of which have still to be published. The work has been undertaken by Professor John Ferguson, Professor E. J. Mills, and Mr. John Robertson, Librarian.

IX. *Proposed New Section*.—A desire has been expressed in favour of forming a Philological Section in connection with the Society, and the paper read in the course of last Session by Dr. James Colville, M.A., aimed at giving some practical direction to that desire. The Council will be glad to give every encouragement to the formation of such a Section of the Society, in order that the study of the Science of Language may make progress under its auspices.

X. *Finance*.—The Treasurer's Statement shows that the last of the Floating Debt, £200, has been practically paid off during the year. This is to be attributed to payments by Life Members on the one hand, and to the considerably diminished general expenditure on the other.

The Council have had under consideration the propriety of Funding—in some form—a proportion of the Life Membership Subscriptions, and now that the Floating Debt is discharged, this subject will have their attention. Ninety-six Members have paid the Life Subscription of £10 10s., yielding £1,008, which has enabled the Society to maintain an equal footing with the Institution of Engineers and Shipbuilders, as co-proprietors of the buildings.

By order and on behalf of the Council.

(Signed) JOHN MAYER,
Secretary.

4. The Report by the Treasurer, giving an Audited Statement of the Funds of the Society, which was signed by Mr. James Muir, C.A., and Mr. Robert Blyth, C.A., and was also printed in the Billet, was held as read, was approved of, and ordered to be printed in the *Proceedings*. The Treasurer likewise submitted an Inventory of the Furniture, &c., belonging to the Society. This was also ordered to be printed in the *Proceedings* for future reference. The following is the Treasurer's Financial Statement:—

Dr.		ABSTRACT OF TREASURER'S	
To FUNDS ON HAND at 1st Nov., 1886,		£21	2 0
„ SUBSCRIPTIONS to 31st Oct., 1887—			
Entry-money from 41 New Members, at 21s.,		£43	1 0
Annual Dues from 2 Members for 1884-85, at 21s.,		£2	2 0
Annual Dues from 10 Members for 1885-86, at 21s.,		10	10 0
Annual Dues from 533 Ordinary Members for 1886-87, at 21s.,		559	13 0
Annual Dues from 35 New Members for 1886-87, at 21s.,		36	15 0
		<hr/>	
		609	0 0
Life Subscription from 6 New Members, at £10 10s.,		£63	0 0
Life Subscription from 5 Old Members, at £10 10s.,		52	10 0
		<hr/>	
		115	10 0
		<hr/>	
		£767	11 0
„ GENERAL RECEIPTS—			
„ Corporation of Glasgow, Interest on “Exhibition Fund” for year to Whitsunday, 1887—less Income Tax.		£19	13 2
„ Bank Interest,		2	8 3
„ Proceedings, Catalogues, &c., sold,		1	5 10½
		<hr/>	
		23	7 3½
„ ARCHITECTURAL SECTION—			
61 Associates' fees for 1886-87, at 5s.,		20	5 0
„ CHEMICAL SECTION—			
10 Associates' fees for 1886-87, at 5s.,		2	10 0
„ GEOGRAPHICAL AND ETHNOLOGICAL SECTION—			
2 Associates' fees for 1884-85, at 5s.,		£0	10 0
7 Do. for 1885-86, at 5s.,		1	15 0
36 Do. for 1886-87, at 5s.,		9	0 0
		<hr/>	
		11	5 0
„ MATHEMATICAL AND PHYSICAL SECTION—			
11 Associates' fees for 1886-87, at 5s.,		2	15 0
„ ECONOMIC SCIENCE SECTION—			
52 Associates' fees for 1886-87, at 5s.,		13	0 0
„ BALANCE due to Treasurer,		18	12 4½
		<hr/>	
		£880	7 11
		<hr/>	

Memo. by Treasurer.—The Amount invested by the Society in the Bath Street Joint Buildings up to 31st October, 1887, is . . . £3,547 8 1½
 whereof, Paid from Society's Funds, £2,047 8 1½
 Do. Society's 'half of £3,000 Bond, . . . 1,500 0 0

£3,547 8 1½

J. M.

ACCOUNT—SESSION 1886-87.

Cr.

By GENERAL EXPENDITURE to 31st October, 1887—

Salary to Secretary,	£75	0	0	
Allowance for Treasurer's Clerks,	15	0	0	
Rent for Joint-Lectures with Scottish Geographical Society,	4	0	0	
Expenses at Lectures,	0	12	6	
				£94 12 6
New Books, Periodicals, and Foreign Periodicals,	£103	13	6½	
Bookbinding,	19	5	0	
Printing Circulars, <i>Proceedings</i> , &c.,	213	17	0	
Lithographs and Woodcuts for <i>Proceedings</i> , &c.,	39	13	6	
Postage and delivery of Circulars, Letters, and Parcels,	36	15	4½	
Stationery, &c.,	2	19	3	
				416 3 8
Fire Insurance on Library for £5,400,	£5	19	9	
Postages, &c.—per Treasurer, £1 17s. 9d.; per Secretary, £5 7s.,	7	4	9	
Frames, Repairs, &c.,	0	17	0	
Interest on Loan of £200,	1	6	0	
				15 7 6
Joint Expenses of Rooms—Society's half of £364 12s. 4d., being Interest on Bond, Insurance, Taxes, Cleaning, Lighting, and Heating; Salaries of Sub-Librarian and Assistant—less half of £94 16s. Revenue from Letting,				134 18 2
„ PRIVATE LOAN repaid,				200 0 0
„ SUBSCRIPTIONS TO SOCIETIES— Ray Society, 1887,	£1	1	0	
Palæontographical Society, 1887,	1	1	0	
				2 2 0
„ ARCHITECTURAL SECTION— Expenses per Treasurer of Section,				8 9 7
„ MATHEMATICAL AND PHYSICAL SECTION— Expenses per Treasurer of Section,				0 5 9
„ GEOGRAPHICAL AND ETHNOLOGICAL SECTION— Expenses per Treasurer of Section,				4 12 6
„ SANITARY AND SOCIAL ECONOMY SECTION— Expenses per Treasurer of Section,				0 2 6
„ ECONOMIC SCIENCE SECTION— Expenses per Secretary of Section,				3 13 9
				£880 7 11

GLASGOW, 10th November, 1887.—We, the Auditors appointed by the Society to examine the Treasurer's Accounts for the year 1886-87, have examined the same, of which the above is an Abstract, and have found them correct, the Balance due to the Treasurer at 31st October last being Eighteen Pounds Twelve Shillings and Fourpence Halfpenny.

(Signed) JAMES MUIR, C.A.
ROBERT BLYTH, C.A.

GRAHAM MEDAL AND LECTURE FUND.

ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1887-88.

Dr.	(PRESENTED TO ANNUAL MEETING.)	Cr.
CAPITAL AT 1ST NOVEMBER, 1886—		
Glasgow and South-Western Railway Co. 4% Preference Stock in name of the Philosophical Society, in Trust, Value of Die at H. M. Mint,	£250 0 0 18 18 0 £268 18 0	£250 0 0 18 18 0 £268 18 0
Cash in Union Bank,	£19 7 8	£0 1 0
Cash in Treasurer's hands,	0 11 8	20 1 0
	19 19 4	9 11 11
REVENUE—		
Dividend, April, 1887, less Tax,	£4 16 8	
" Oct. " " "	4 16 11	
	9 13 7	
	£298 10 11	£298 10 11
		WM. WALLACE, Treasurer.

5. Mr. JOHN ROBERTSON, Librarian and Convener of the Library Committee, read the Annual Report on the state of the Library. This, which was also printed in the Billet, was unanimously adopted, and ordered to be printed in the *Proceedings*. Mr. Robertson likewise submitted a number of the Presentations which had been made to the Library. The Report was as follows:—

REPORT OF THE LIBRARY COMMITTEE.

The Library Committee have pleasure in reporting that the number of members to whom books were issued during the past year has considerably increased. The issue amounted to 946 volumes, which were taken out by 649 members.

At present 99 periodicals are received at the Library. Of these, 64 are bought and 35 presented, forming altogether 144 volumes a year. The "British Journal of Photography," "The Economist," "Industries," "Zeitschrift für die Chemische Industrie," and the "Quarterly Journal of Economics," have been added since last Report.

The Presentations to the Society during the year included 34 volumes, 12 parts of works, and 45 pamphlets, while 47 volumes and 148 parts of works were received in exchange from 155 Societies and Public Departments. There were purchased 52 volumes and 9 parts. The total additions to the Library for the year amount to 277 volumes, 157 parts, and 45 pamphlets.

Since last Report correspondence has been opened up with the Canadian Society of Engineers; Folkestone Natural History Society; Sociedad Científica "Antonio Alzate," Mexico; and Der Wissenschaftliche Verein zu Santiago, Chili; Oberhessische Gesellschaft für Natur und Heilkunde, Giessen; Manchester Association of Engineers.

In Volume XVIII. of the *Proceedings*, pp. 437-445, will be found a list of the additions to the Library by purchase during last session, the titles of the volumes presented, with the names of the donors; the names of the Societies and Public Departments with which exchanges are effected, and a complete list of the periodicals received by the Society.

During the year 98 volumes were bound.

The estimated number of volumes in the Library is 10,112. New book-cases have been provided for the better accommodation of the rapidly increasing Library of the Society.

JOHN ROBERTSON, LIBRARIAN,
Convener.

6. On the motion of the PRESIDENT, a very hearty vote of thanks was awarded to Mr. Mann and Mr. Robertson for the excellent services which they had rendered to the Society during the past year.

7. The Society then proceeded to the election of Office-bearers:—

- (1) For the vacant Vice-Presidentship, caused by the retiral of Dr. W. G. BLACKIE, by rotation, Dr. JOHN G. M'KENDRICK, F.R.S., had been recommended by the Council; and on being formally proposed by the President, he was elected with acclamation.
- (2) On the Motion of the President, Messrs. ROBERTSON and MANN were unanimously re-elected to their respective offices of Librarian and Treasurer.
- (3) Before proceeding to the election of the Secretary, the President announced that—in his unavoidable absence, which he very greatly regretted—Dr. M'KENDRICK had addressed to him a note, which had already been read to a Meeting of Council, and which he desired should also be read to the Annual Meeting of the Society. It stated that it would have given him pleasure, and he would have considered it to be only his duty, to have given his testimony as to the thorough and efficient way in which Mr. JOHN MAYER had discharged the duties of Secretary during the past year. The President then formally moved the re-election of Mr. MAYER, which was unanimously agreed to.
- (4) The President announced that there were six vacancies in the Council to be filled—four of them being due to the retiral, by rotation, of Mr. Alexander Whitelaw, Mr. A. Lindsay Miller, Mr. Robert Goodwin, and Dr. J. M'Gregor Robertson; one to the election of Dr. M'Kendrick to a Vice-Presidentship; and one caused by the resignation of Mr. R. F. Muirhead, who had gone to London. Mr. WILLIAM MILNE, on behalf of the Council, nominated the following gentlemen:—Mr. Adam Knox, engineer; Dr. Thomas Muir, M.A., F.R.S.E., of the High School; Dr. John Glaister; Mr. J. T. Bottomley, M.A., F.R.S.E.; Mr. John Farquhar, merchant; and Mr. Wallace Fairweather, C.E. There being no other nominations, those gentlemen were declared elected—Mr. Fairweather, in room of Mr. Muirhead, to serve one year; Mr. Farquhar, in room of Dr. M'Kendrick, to serve two years; and the other gentlemen named to serve the ordinary period of three years.
- (5) Various Office-bearers of the Geographical and Ethnological Section were appointed, according to resolution of the Society of 11th April, 1883; and of the Chemical, Biological, Sanitary and Social Economy, Mathematical and Physical, and Economic Science Sections, in accordance with resolutions of Society of 18th November, 1885, and 2nd February, 1887.

8. At the close of the business proper to the Annual Meeting, the President referred to the death of Dr. Fergus, which took place during the summer recess, and he moved the following resolution, which was unanimously approved of:—"That we record

our grateful recollection of the services rendered to the Society by the late Dr. Andrew Fergus during many years, and in many ways, but especially during his Presidentship, in connection with the erection of the buildings which we now occupy, and the incorporation of the Society; also our sense of the great loss the Society has sustained in his death: that an extract of this Minute be forwarded to Mrs. Fergus, with an expression of our deep sympathy with her and her family in their bereavement."

9. Mr. WILLIAM SMART, M.A., Lecturer on Political Economy, Vice-President of the Economic Science Section, read a paper on "Factory Industry and Socialism," being a communication from that Section. The author was cordially thanked for his paper, and the discussion of it was held over for the opening meeting of the Section.

10. Mr. D. SINCLAIR, Engineer to the National Telephone Company, exhibited and briefly described a set of Instruments for a new Ring-off System applicable to Telephone Exchanges and other purposes. He was awarded the thanks of the Society for his communication.

11. The following gentlemen were declared to have been duly elected into the Society:—Mr. David S. Miller, commission merchant, 1 Royal Terrace, West; Mr. Charles H. Yeaman, electrical engineer, 2 Albany Place; Mr. James Thyne McCallum, florist, 83 St. Vincent Street; Mr. J. Carfrae Alston, merchant, 9 Lorraine Gardens, Dowanhill; Mr. Thomas Gray, B.Sc., F.R.S.E., Physical Laboratory, University of Glasgow; Mr. Thomas J. Menzies, M.A., B.Sc., F.C.S., head-master, Stonelaw School, Rutherglen; Mr. Matthew Edwards, optician, 209 Sauchiehall Street; Mr. David Reid, philosophical instrument maker, 209 Sauchiehall Street; and Mr. Matthew Blair, yarn merchant, 11 Hampton Court Terrace.

30th November, 1887.

The Second Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 30th November, 1887, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Annual General Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. David S. Miller, Mr. Charles H. Yeaman, Mr. James Thyne M'Callum, Mr. J. Carfrae Alston, Mr. Thomas Gray, B.Sc., F.R.S.E.; Mr. Thomas J. Menzies, M.A., B.Sc., F.C.S.; Mr. Matthew Edwards, Mr. David Reid, and Mr. Matthew Blair were admitted to the Membership of the Society.

3. Mr. Henry Dyer, C.E., M.A., Member of Council, read a paper on "The Technical Schools (Scotland) Act, and its Relations to Elementary and Higher Education," for which he was awarded a vote of thanks. A discussion ensued, in which the speakers were—Sir John Cuthbertson, Miss Grace Paterson, Mr. J. H. Kerr, and Mr. William Mitchell, Members of the Glasgow School Board; Mr. William Jolly, H.M. Inspector of Schools; Dr. Thomas Muir, and Mr. R. C. Grant, ex-Chairman of the Glasgow Trades Council.

4. The President announced that the following gentlemen had been duly elected into the Society:—Mr. Thomas Richmond, L.R.C.P.E., surgeon, 26 Burnbank Terrace; Mr. Paul Fernau, merchant, 6 Broomhill Avenue, Partick; Dr. Freeland Fergus, F.F.P.S.G., 191 Bath Street; Mr. Matthew P. Fraser, writer, 91 West Regent Street; Mr. Alexander Galt, B.Sc., F.R.S.E., F.C.S., science demonstrator, 9 Park Place, Rutherglen; Mr. John Young, M.A., B.Sc., secretary, Glasgow and West of Scotland Technical College; Mr. John A. Warren, civil engineer, 115 Wellington Street.

14th December, 1887.

The Third Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 14th December, 1887, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Second Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. Thomas Richmond, Mr. Paul Fernau, Dr. Freeland Fergus, Mr. Matthew P. Fraser, Mr. John Young, and Mr. John A. Warren were admitted to the Membership of the Society.

3. Dr. Eben. Duncan read a Biographical Notice of the late Dr. Andrew Fergus, a former President of the Society. On the motion of the President, Dr. Duncan was awarded the thanks of the Society for his communication. Dr. Russell then read the following reply from Mrs. Fergus to the vote of sympathy which was passed at a former Meeting of the Society :—

“191 BATH STREET,

“GLASGOW, *December 2nd.*

“THE SECRETARY OF THE PHILOSOPHICAL SOCIETY.

“DEAR SIR,

“On behalf of myself and my family, I beg to thank the President and Gentlemen of the Philosophical Society for their kind sympathy with us in our unspeakable bereavement. Many a happy night my dear husband spent in the Society's meetings, and many a dear friend he had among its Members. I remember how pleased he was when the new building was completed, and how he insisted that I should go over and see it; and also his name on the glass of the staircase window. We can never cease to take an interest in the Society's progress and well-being, and trust that all its Members may be as devoted to its success as he was who is still so kindly remembered.

“I remain, DEAR SIR,

“Yours most truly,

“MARGARET FERGUS.”

4. Professor M'Kendrick read a paper on “The Modern Cell Theory and the Phenomena of Fecundation,” for which he received the hearty thanks of the Society.

5. The President announced that Mr. William Bathgate, M.A., H.M. inspector of schools, 11 Hamilton Drive; and Mr. Henry A. Mavor, electrician, 140 Douglas Street, had been duly elected Members of the Society; and he also announced that, on account of the Christmas and New Year Holidays, the next Meeting of the Society would not be held till 11th January, 1888.

11th January, 1888.

The Fourth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on

the Evening of Wednesday, 11th January, 1888, at Eight o'clock
—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Third Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. William Bathgate, M.A., and Mr. Henry A. Mavor were admitted to the Membership of the Society.

3. Mr. William Bottomley, C.E., read a paper on "The Heeling Error of the Compass in Iron Ships." Some remarks were made on the subject of the paper by Mr. Nathaniel Dunlop and Mr. Thomas Gray, and the thanks of the Society were passed to Mr. Bottomley.

4. Dr. James Colville, M.A., read a paper on "Public Museums as Aids in Teaching." In the discussion to which the paper gave rise, remarks were made by the President, Mr. Dyer, Mr. James Paton, Curator of Museum and Galleries; and Mr. John Lochore, Fairfield Public School. On the motion of the Chairman, a vote of thanks was awarded to Dr. Colville for his suggestive paper.

5. The President announced that Mr. William Macfarlane, papermaker, Edina Lodge, Rutherglen; Bailie James M'Lennan, wine merchant, St. Andrew Street; Councillor Robert Graham, wholesale bookseller and news agent, 61 Eglinton Street; Councillor Thomas Cumming, merchant, North Wallace Street; and Bailie William Stevenson, quarrymaster, 21 Clyde Place, had been duly elected Members of the Society.

25th January, 1888.

The Fifth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 25th January, 1888, at Eight o'clock
—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Fourth Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were admitted:—Mr. William Macfarlane, Edina Lodge, Rutherglen; Bailie James M'Lennan, Councillor Robert Graham, Councillor Thomas Cumming, and Bailie William Stevenson.

3. Mr. Alfred E. Fletcher, F.C.S., F.I.C., London, H.M. Chief Inspector under the Alkali, &c., Works Regulation Act, read a paper on "Noxious Vapours and Town Smoke, with Suggestions on House Warming." A discussion took place, in which the speakers were—the President, Mr. D. M. Nelson, Mr. John Brown, Mr. Alexander Sinclair, Mr. David Cowan, Carron Ironworks; Mr. J. J. Coleman, Mr. Wallace Fairweather, Mr. E. C. C. Stanford, Mr. W. Foulis, Mr. W. R. W. Smith, Mr. M'Phee, Procurator-Fiscal; and Mr. Charles Wilson. Mr. Fletcher was awarded a cordial vote of thanks.

4. The President announced the election of the following gentlemen as Members of the Society:—Mr. D. Johnstone Smith, C.A., 149 West George Street; Mr. William Harvie, lamp maker, 222 Broomielaw; Mr. William V. Jackson, secretary, Industry Defence Association, 237 Ingram Street; and Mr. William Brown, 22 Westminster Terrace.

8th February, 1888.

The Sixth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Natural Philosophy Class-Room, University of Glasgow, on the Evening of Wednesday, 8th February, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Fifth Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were admitted:—Mr. D. Johnstone Smith, C.A., 149 West George Street; Mr. William Harvie, lamp maker, 222 Broomielaw; Mr. William V. Jackson, secretary, Industry Defence Association, 237 Ingram Street; Mr. William Brown, 22 Westminster Terrace.

3. Professor M'Kendrick exhibited and briefly described—(a) E. Von Fleischl's Spectro-polarimeter for the Estimation of Grape Sugar; (b) a Gas Pump for the removal of Gases from the Blood; (c) a Centrifugal Apparatus for the separation of the Red Blood Corpuscles; (d) Kronecker's Electro-myographion for the study of Muscular Contraction. A cordial vote of thanks was awarded to Dr. M'Kendrick.

4. Sir William Thomson, LL.D., D.C.L., F.R.S., made a Communication on "A New Composite Form of Electric Balance adapted to measure currents from $\frac{1}{10}$ of an ampère to 500 ampères: available also as a Volt-meter and as a Watt-meter," for which he was awarded a hearty vote of thanks.

5. The President announced the election of the following gentlemen as Members of the Society:—Mr. Alexander M'Ara, merchant, 65 Morrison Street; Mr. John Paterson, contractor, 522 Pollokshaws Road; Mr. William Macintyre, head master, Bridgeton Parish School, Marion Bank, Rutherglen; Mr. Robert H. Robertson, finisher, Clyde Bank, Rutherglen; Mr. John C. Rogers, Vice-Consul, Republic of Chili, 163 West George Street; and Mr. David Cowan, manager for Carron Company, Mount Gerald, Larbert.

14th February, 1888.

The Seventh Ordinary Meeting of the Philosophical Society of Glasgow was held in the Rooms of the Society, 207 Bath Street, on the Evening of Wednesday, 22nd February, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Sixth Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were admitted:—Mr. Alexander M'Ara, Mr. John Paterson, Mr. William Macintyre, Mr. Robert H. Robertson, Mr. John C. Rogers, and Mr. David Cowan.

3. Mr. Thomas Gray, B.Sc., F.R.S.E., exhibited and described an Improved Form of Seismograph; and he subsequently read a

paper on "The Use of Seismometric Measurement in Earthquake Investigation." Some remarks were made on the subject by the President, Sir William Thomson, and Mr. D. Sinclair; and the thanks of the Society were awarded to Mr. Gray.

4. Mr. A. W. Meikle, "Thomson" Experimental Scholar, read a paper entitled "On the Measurement of Electric Currents by the Electrolytic Deposition of Copper," for which he was awarded the thanks of the Society.

5. Dr. James Colville, M.A., submitted the following motion:—"That a Philological Section of the Philosophical Society be formed, and that a committee, to be afterwards named, be appointed to draft a constitution for the Section." The motion was seconded by Mr. D. G. Hoey, and agreed to by the Meeting. A committee was then named, consisting of Dr. Thomas Muir, Rev. Professor Robertson, Mr. Dyer, Mr. Hoey, and Dr. Colville.

6. The President announced the election of the following gentlemen as members of the Society:—Mr. G. J. Miller, of Frankfield, Shettleston; Mr. H. G. Finlay, 11 Granby Terrace, Glasgow; and Mr. A. D. Provand, M.P., 8 Bridge Street, London, S.W.

7th March, 1888.

The Eighth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 7th March, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Seventh Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were admitted:—Mr. G. J. Miller, of Frankfield, Shettleston; Mr. H. G. Finlay, 11 Granby Terrace; and Mr. A. D. Provand, M.P., 8 Bridge Street, London, S.W.

3. Mr. John Galloway read a paper on "The Plate River System," being a communication from the Geographical and

Ethnological Section. On the motion of Dr. Thomas Muir, Vice-President of the Section, the thanks of the Society were awarded to Mr. Galloway.

4. Mr. John Aitken, F.R.S.E. (by special request of the Council of the Society), explained "A Method of Counting the Dust Particles in the Atmosphere," and gave an experimental demonstration, for which he was awarded the thanks of the Society.

5. Dr. James Colville, M.A., made a brief statement regarding the proposed Constitution of the Philological Section, and gave notice that he would move its adoption at next Meeting of the Society.

6. The President announced the election of the following gentlemen as Members of the Society:—Mr. Arthur Coulson, electrical engineer, 140 Douglas Street; Mr. William Wallace, M.A., M.B., C.M., Westfield House, Shawlands; and Mr. James Kean, philosophical instrument maker, 96 Thistle Street, Garnethill.

21st March, 1888.

The Ninth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 21st March, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the chair.

1. The Minutes of the Eighth Ordinary Meeting of the Society, which were printed in the notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were admitted:—Mr. Arthur Coulson, Mr. William Wallace, M.A., M.B., C.M.; and Mr. James Kean.

3. Mr. A. Ernest Maylard, B.S., M.B., by special request, gave "A Demonstration in Bacteriology," illustrative of the Mode of Growth and Cultivation of Micro-Organisms found in the Air, in Water, and in the Earth, embracing also some of those which give rise to Disease." The thanks of the Meeting were awarded to Mr. Maylard for his paper and demonstration, and a discussion

took place, in which the speakers were the President, Dr. Joseph Coats, Professor Sir George Macleod (present by invitation), Dr. Gairdner, Professor Bower, and Dr. Duncan.

4. Dr. James Colville, M.A., moved the adoption of the Constitution of the Philological Section, which had been printed in the Billet. The motion was seconded by Mr. Dyer, and agreed to by the Meeting. The Constitution is as follows:—

(1) The Section shall be called the PHILOLOGICAL SECTION.

(2) The object of the Section shall be to aid the advancement of Philology by affording opportunities for the discussion of subjects related thereto, to be introduced by the reading of papers or by verbal communication. The papers may also be read before the Society, according as the Council of the Section may see fit to recommend to the Council of the Society.

(3) The Section shall consist of Members of the Philosophical Society, who are to be admitted free to its meetings, and of Associates who are not Members of the Philosophical Society, but shall be admitted to the Section on payment of an Annual Subscription of Five Shillings. Associates shall have the privilege of attending not only the Section's meetings, but also those of the Society at which the Section's papers are read and discussed, and also of consulting the books in the Library.

(4) The management of the Section shall devolve upon a Council, consisting of a President, two Vice-Presidents, a Secretary (who shall act as Treasurer), and nine other Members.

(5) The Secretary shall be elected annually. After the first year four Members of Council shall retire annually in rotation, the order to be determined by ballot on the first occasion of an election. Retiring Members shall be eligible for re-election. Three shall be a quorum.

(6) The Office-bearers of the Section shall be elected by the Society at its Annual Business Meeting.

(7) Vacancies occurring during the currency of a year may be filled up, *ad interim*, by the Council of the Section, if they deem it expedient.

(8) The Council of the Section shall report annually to the Society.

(9) No paper shall be read that has not been approved by the Council of the Section; and copies of the papers shall be given into the charge of the Secretary of the Section at the close of the meeting at which they have been read.

(10) Associates shall be elected by the Council of the Section at any of its meetings. Each Candidate shall be recommended by two Members or Associates. The vote shall be by ballot, a majority deciding.

(11) The Associates' Annual Subscription shall become due on the First day of November in each year.

(12) No alteration shall be made upon the foregoing without the consent of the Society at two successive ordinary meetings.

4th April, 1888.

The Tenth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 4th April, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Ninth Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following Candidate for election into the Society was announced :—Mr. Thomas Leonard Ellis, iron manufacturer, North British Iron Works, Coatbridge. Recommended by Mr. Fairweather, Mr. John Mann, and Mr. Mayer.

3. Dr. David Pride, Neilston, read a paper on "The Spread of Enteric Fever and, possibly, Diphtheria in Rural Districts, by the Use of City Manure for Agricultural Purposes." A discussion followed, in which the speakers were—the President, Dr. Eben. Duncan, Mr. J. Chalmers (Architect), Dr. Glaister, Mr. R. R. Tatlock, Mr. Young (Inspector of Cleansing), Mr. W. R. W. Smith, Dr. Christie, and Mr. Leitch. Dr. Pride replied, and he received the thanks of the Society for his paper.

4. In consideration of the importance of the paper by Mr. Peter Fyfe (announced in the Billet), and the other business to be brought forward, it was agreed, on the motion of Dr. Duncan, seconded by Mr. W. R. W. Smith, to take it up at a Special Meeting of the Society to be held on 11th April.

5. In the absence of Dr. Colville, the election of the list of proposed Office-bearers of the Philological Section, which had been printed in the Billet, was agreed to, on the motion of Mr. Dyer, seconded by Mr. Alex. Scott. The list is as follows :—

President.

R. C. JEBB, LL.D., Professor of Greek, University of Glasgow.

Vice-Presidents.

Rev. W. A. SKEAT, M.A., Professor of Anglo-Saxon, University of Cambridge.

Rev. JAS. ROBERTSON, D.D., Professor of Oriental Languages, University of Glasgow.

Council.

Dr. DAVID ROSS.
Dr. JAS. MACDONALD.
Mr. W. BATHGATE, M.A., H.M.I.S.
Mr. JAS. MORRISON.
Mr. F. AMOURS, B.A.

Mr. WM. THOMSON, B.A.
Mr. JUSTUS WIDMER.
Mr. D. G. HOEY, C.A.
Mr. E. J. GIBB.

Secretary and Treasurer.

JAS. COLVILLE, M.A., D.Sc.

6. The following motion, of which notice had been given, was proposed by Dr. Duncan, and seconded by Mr. W. R. W. Smith:—

“That the Society memorialise the Secretary of State for Scotland to take steps for the amendment of the Burials Act, so as to place the Private Cemetery Companies of Scotland under the regulations issued by the Home Secretary in 1863 for the Burial Grounds under the Burials Act; and that it be remitted to the Council of the Sanitary and Social Economy Section to prepare the Memorial on behalf of the Society.”*

Mr. Scott moved “the previous question” as an amendment, which was seconded by Mr. Church. After remarks by Dr. Christie, the President, Sheriff Spens, Mr. D. G. Hoey, Dr. Glaister, and Dr. Duncan, the amendment was withdrawn, and the motion was passed.

7. Dr. Duncan then submitted the following Motion, notice of which had also been given:—

“That it be remitted to the Council of the Sanitary and Social Economy Section to consider what other reforms are required on our present methods of disposal of the dead; and to report.”

The Motion was seconded by Mr. W. P. Buchan, and agreed to.

11th April, 1888.

A Special Meeting of the Society was held on the Evening of Wednesday, 11th April, at Eight o’Clock—Dr. J. B. Russell, President, in the Chair.

Mr. Peter Fyfe, Sanitary Inspector, Glasgow, read a paper on “Some Important Points in the Sanitary Work of a Great City.” It gave rise to a long and animated discussion, in which the speakers were—The President, Sir James Bain, Mr. Gilbert

* See Memorial, page 410.

Beith, Mr. D. M. Nelson, Mr. Hogg, Dr. Duncan, Mr. Honeyman, Mr. Westlands, Dr. Glaister, Dr. Christie, Mr. J. Cleland Burns, Mr. Chalmers, and Mr. Buchan. Mr. Fyfe replied, and he was awarded a vote of thanks for his paper.

18th April, 1888.

The Eleventh Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 18th April, 1888, at Eight o'clock—Dr. J. B. Russell, President, in the Chair.

1. The Minutes of the Tenth Ordinary Meeting of the Society, and of a Special Meeting (held 11th April), which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The President read a letter from Mr. Wm. Alex. Smith, expressing regret that he was unable to submit the paper, which he had promised to read to the Society, on "Decimal Coinage."

3. Dr. Alexander Buchan, Secretary to the Scottish Meteorological Society, communicated a paper on "The Diurnal Phenomena of Weather in their Relation to each other." A vote of thanks was awarded to Dr. Buchan.

4. The President announced that Mr. Thomas Leonard Ellis had been elected a Member of the Society.

2nd May, 1888.

The Twelfth Ordinary Meeting of the Philosophical Society of Glasgow—the last for the Session—was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 2nd May, 1888, at Eight o'clock—Mr. Henry Dyer, Member of Council, in the Chair.

1. The Minutes of the Eleventh Ordinary Meeting of the Society, which were printed in the Notice calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The Secretary read a note from the President apologising and expressing regret for his absence, which was due to an injury which he had received.

3. Professor Blyth, M.A., F.R.S.E., read a paper on "The Practical Application of Wind Power to the Production and Storage of Electricity." A discussion took place in which the speakers were—The Chairman, Mr. Thomas Gray, Mr. D. Sinclair, and Mr. Mechan. Professor Blyth was awarded the thanks of the Society for his communication.

4. Mr. Thomas Shields, M.A., Physical Laboratory, University of Glasgow, read a paper on "The Electric Resistance of some Rocks." He was thanked for his communication, and remarks were made upon it by Mr. Gray, Professor Blyth, and Mr. Sinclair.

5. Mr. Thomas Machell read a paper on "The Dulcitone; a New and Portable Musical Instrument, having Forks of Steel for its Sound Producers." Several of his completed instruments were shown by the inventor, who also gave illustrations of their capabilities. The thanks of the Society were voted to Mr. Machell; and in the discussion which followed the speakers were Mr. Colin Brown, Rev. Mr. Brunton, Professor Blyth, Dr. Muir, Mr. Mechan, and Mr. Alex. Scott.

6. A letter from Mr. J. J. Coleman was read by the Secretary, in which the writer spoke of the work done in connection with the Glasgow and West of Scotland Technical College, in the management of which he had acted as the representative of the Society.

7. The Secretary submitted the Report by Mr. W. C. Crawford, Delegate to the British Association held at Manchester last year, and the Reports for the past Session from the Secretaries of Sections. These were all held as read, and ordered to be printed in the *Proceedings*, Mr. Coleman's letter included.

BURIAL REFORM.*

**TO THE RIGHT HONOURABLE THE MARQUIS OF LOTHIAN,
K.T., HER MAJESTY'S SECRETARY FOR SCOTLAND.**

THE MEMORIAL OF THE PHILOSOPHICAL SOCIETY OF GLASGOW.

THE Philosophical Society of Glasgow, now holding its Eighty-fifth Session, consists of 700 members, representing the professions, the arts, manufactures, and trade and commerce of the City of Glasgow. The Philosophical Society has a Section for the special consideration of matters relating to Sanitary and Social Economy, many of the members of which have had large experience in practical hygiene.

That the Society, both in the Council of its Sanitary and Social Economy Section, and also in general meetings, has had under consideration the present methods of burial of the dead, and particularly of the bodies of the poorer classes in the Burial Grounds and Private Cemeteries of Scotland.

That the Society is unanimously of the opinion that the interment of the dead as at present conducted by many of the private cemetery companies, on the system of pit burial, is likely to lead to grave sanitary dangers, and is offensive to public decency.

That in the burial grounds of Glasgow and its suburbs several thousands of bodies of paupers and others of the poorer classes are annually interred in pits and common graves.

That many of these pits and common graves are left open until they are filled up with coffins to within three feet of the surface of the ground.

That during this time the coffins in these pits and common graves are either exposed, or are covered with a mere sprinkling of sand or earth.

That these pits and common graves vary in size, the smallest of which this Society is cognisant containing five coffins, the largest sixty coffins.

* See Minutes of Session, page 407.

That considerable areas of ground in the neighbourhood of Glasgow are being occupied with masses of decomposing bodies deposited in this dangerous manner.

That the cemeteries which adopt this system are already in close proximity to dwelling-houses, which are increasing so rapidly in numbers in the respective localities that these cemeteries will soon be surrounded by them.

That the interments in the burial grounds in other districts of Scotland have been found to be conducted in a manner dangerous to health, and offensive to public decency.

That the chief causes of the growth of the objectionable and dangerous methods of interment above referred to are (1) that, under clause 12 of the Burial Grounds (Scotland) Act, 1855 (18 and 19 Vic., c. 67)—[See Appendix A.]—public authorities, in lieu of providing ground for the proper interment of the people, have contracted with private cemetery companies to bury for them the bodies of persons who would have a right to interment in burial grounds to be provided under the Act; and (2) that the cemetery companies of Scotland have assumed that they are not subject to any control under the burials act.

The Society is aware that under the powers given by clause 21 of the Burial Grounds (Scotland) Act, 1855—[See Appendix B.]—the Secretary of State may make regulations as to burial grounds "for the protection of public health and decency," but the Society is not aware that any such regulations have been issued under that Act.

The Society is, however, aware that regulations for the protection of public health and decency were issued in 1863, for burial grounds in England. But it does not clearly appear whether even these regulations apply to the burial grounds of private cemetery companies. Moreover, as regards Scotland it seems doubtful whether under the Scotch Burials Act any valid regulations could be issued by the Secretary of State with reference to private cemetery companies.

That the English regulations referred to—[See Appendix C.]—are, in the opinion of the Society, reasonable and proper regulations.

That similar regulations are absolutely necessary in the case of private cemetery companies is shown by the facts already stated.

That, as pit burial is cheaper than burial under the conditions held to be necessary by the Secretary of State "for the protection

of public health and the maintenance of public decency," and as it is also more profitable to the cemetery companies, it will continue to be adopted in Scotland unless measures be taken to put an end to it.

The Philosophical Society would, therefore, respectfully submit the above statement for the consideration of Her Majesty's Government, in the hope that effectual means may be devised to put an end to the dangerous and offensive system of burial herein described.

JAS. B. RUSSELL, M.D., LL.D.,
President of the Society.

JOHN MAYER,
Secretary.

EBEN. DUNCAN, M.D.,
*President of the Sanitary and Social
Economy Section.*

GLASGOW, 16th July, 1888.

APPENDIX.

Burial Grounds (Scotland) Act, 1855.

[A.] XII.—For the providing such burial ground, it shall be lawful for the Parochial Board of the parish to contract for and purchase or take any lands and buildings thereon for the purpose of forming a burial ground, or for making additions to any burial ground to be formed or purchased under this Act, as such board may think fit, or to purchase from any company or persons entitled thereto any cemetery or cemeteries, or part or parts thereof, subject to the rights in vaults and graves and other subsisting rights which may have been previously granted therein; provided always that it shall be lawful for such board, in lieu of providing any such burial ground, to contract with any such company or persons entitled as aforesaid for the interment in such cemetery or cemeteries, and either in any allotted part of such cemetery or cemeteries or otherwise, and upon such terms as the Parochial Board may think fit, of the bodies of persons who would have had rights of interment in the burial grounds of such parish.

[B.] XXI.—It shall be lawful for one of Her Majesty's principal Secretaries of State, from time to time, to make such regulations in relation to the burial grounds and places of reception of bodies previous to interment which may be provided under this Act as to him may seem proper for the protection of the public health and the maintenance of public decency; and the parochial boards and all other persons having the care of such burial grounds

and places for the reception of bodies shall conform to and obey such regulations.

[C.] REGULATIONS FOR BURIAL GROUNDS PROVIDED UNDER
THE BURIALS ACTS.

ISSUED BY THE SECRETARY OF STATE FOR THE HOME DEPARTMENT,
JANUARY, 1863.

*Supplement to the Tenth Annual Report of the Local Government Board,
page 151.*

1. The burial ground shall be effectually fenced, and, if necessary, under-drained to such a depth as will prevent water remaining in any grave or vault.
2. The area to be used for graves shall be divided into grave spaces, to be designated by convenient marks, so that the position of each may be readily determined, and a corresponding plan kept on which each grave space shall be shown.
3. The grave spaces for the burial of persons above 12 years of age shall be at least 9 feet by 4 feet, and those for the burial of children under 12 years of age, 6 feet by 3 feet, or, if preferred, half the measurement of the adult grave space, namely, 4½ feet by 4 feet.
4. A register of graves shall be kept, in which the name, age, and date of burial in each shall be duly registered.
5. No body shall be buried in any vault or walled grave unless the coffin be separately entombed in an air-tight manner; that is, by properly-cemented stone or brickwork, which shall never be disturbed.
6. One body only shall be buried in a grave at one time, unless the bodies be those of members of the same family.
7. No unvalled grave shall be reopened within 14 years after the burial of a person above 12 years of age, or within 8 years after the burial of a child under 12 years of age, unless to bury another member of the same family, in which case a layer of earth not less than 1 foot thick shall be left undisturbed above the previously-buried coffin; but if, on reopening any grave, the soil be found to be offensive, such soil shall not be disturbed, and in no case shall human remains be removed from the grave.
8. No coffin shall be buried in any unvalled grave within 4 feet of the ordinary level of the ground, unless it contains the body of a child under 12 years of age, when it shall not be less than 3 feet below that level.

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Royal Cornwall Polytechnic Society,	Falmouth.
Royal Dublin Society,	Dublin.
Royal Geographical Society,	London.
Royal Geographical Society,	Vienna.
Royal Institute of British Architects,	London.
Royal Institute of Lombardy,	Milan.
Royal Institution of Cornwall,	Truro.
Royal Institution of Great Britain,	London.
Royal Irish Academy,	Dublin.
Royal Microscopical Society,	London.
Royal Physical Society of Edinburgh,	Edinburgh.
Royal Prussian Academy of Science,	Berlin.
Royal Scottish Society of Arts,	Edinburgh.
Royal Society of Canada,	Quebec.
Royal Society of Edinburgh,	Edinburgh.
Royal Society of London,	London.
Royal Society of Tasmania,	Hobart Town.
Royal Society of Victoria,	Melbourne.
School of Mines,	New York.
Science,	Cambridge, Mass.

Science Monthly,	London.
Scottish Geographical Society,	Edinburgh.
Scottish Meteorological Society,	"
Seismological Society of Japan,	Tokio.
Smithsonian Institution,	Washington.
Social Science Association,	London.
Societal Cientifica "Antonio Alzate,"	Mexico.
Society for Psychical Research,	London.
Société des Sciences Physiques et Naturelles,	Bordeaux.
Société Royal des Sciences de Liège,	Liège.
Society of Arts,	London.
Society of Chemical Industry,	London.
Society of Engineers,	"
South Wales Institute of Engineers,	Swansea.
Statistical Society,	London.
United States Geologist,	Washington.
United States Observatory,	"
United States Survey,	"
University of Christiania,	Christiania.
University of Tokio, Japan,	Tokio, Japan.
Verein für Erkunde zu Halle,	Halle.
Videnskabs-Selskabet i Christiania,	Christiania.
Washburn Observatory—University of Wisconsin,	Washburn.
Wagner Free Institute of Science,	Philadelphia.
Wissenschaftliche Verein zu Santiago,	Santiago, Chile.

LIST OF PERIODICALS.

WEEKLY.

Academy.	Engineering.
Architect.	English Mechanic.
Athenæum.	Industries.
British Architect.	Iron.
British Journal of Photography.	Journal of the Society of Arts.
British Medical Journal.	Journal of Gas Lighting.
Builder.	Mechanical World.
Building News.	Nature.
Chemical News.	Notes and Queries.
Comptes Rendus.	Pharmaceutical Journal.
Dingler's Polytechnisches Journal.	Science.
Economist.	Scientific American.
Electrician.	Telegraphic Journal.
Engineer.	

FORTNIGHTLY.

Berichte der Deutschen Chemischen Gesellschaft.	Journal für Praktische Chemie.
Bulletin de la Société Chimique de Paris.	Zeitschrift für die Chemische Industrie.

MONTHLY.

American Journal of Science and Arts.	Journal of the Franklin Institute.
Annales de Chimie et de Physique.	Journal de Pharmacie et de Chimie.
Annales des Ponts et des Chaussées.	Journal of Botany.
Annales des Sciences Naturelles—Botanique.	Monthly Notes of the Library Association.
Annales des Sciences Naturelles—Zoologie.	Journal of the Photographic Society.
Annalen der Chemie.	Journal of Science.
Annalen der Physik und Chemie.	Journal of the Chemical Society.
Annals and Magazine of Natural History.	Journal of the Scottish Geographical Society.
Analyst.	London, Edinburgh, and Dublin Philosophical Magazine.
Antiquary.	Midland Medical Miscellany.
Beiblätter zu den Annalen der Physik und Chemie.	Midland Naturalist.
Bulletin de la Société d'Encouragement.	Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
Bulletin de la Société Géologique de France.	Odontological Society's Transactions.
Bulletin Mensuel de l'Observatoire de Montsouris.	Proceedings of Royal Society of London.
Canadian Entomologist.	Proceedings of Royal Geographical Society.
Chamber of Commerce Journal.	Royal Astronomical Society's Monthly Notices.
Entomologist.	Sanitary Journal.
Entomologists' Monthly Magazine.	Science Monthly.
Geological Magazine.	Zoologist.
Hardwicke's Science Gossip.	

QUARTERLY.

Annales des Mines.	Quarterly Journal of Economics.
Bulletin de la Société Industrielle de Mulhouse.	Quarterly Journal of Geological Society.
Grevillea.	Quarterly Journal of Microscopical Science.
Journal of Anatomy and Physiology.	Quarterly Journal of Ornithology.
Journal of the Royal Agricultural Society of England.	Quarterly Journal of Pure and Applied Mathematics.
Journal of the Scottish Meteorological Society.	Revue Universelle des Mines.
Journal of the Statistical Society.	Scientific Roll.
Mind: a Quarterly Review of Psychology and Philosophy.	Zeitschrift für Analytische Chemie.

LIST OF MEMBERS
OF THE
PHILOSOPHICAL SOCIETY OF GLASGOW,
FOR 1887-88.

HONORARY MEMBERS.

(Limited to Twenty.)

WITH YEAR OF ELECTION.

FOREIGN.

	Michael Eugene Chevreul, Paris.	1860
	Hermann Ludwig Ferdinand von Helmholtz, Berlin.	1860
	Rudolph Albert Kolliker, Würzburg.	1860
	Wilhelm Weber, Göttingen.	1860
5	Ernst Heinrich Haeckel, Jena.	1880
	Louis Pasteur, Paris.	1885
	Frans Cornelius Donders, Utrecht.	1887

AMERICAN AND COLONIAL.

	James Dwight Dana, LL.D., Professor of Geology and Mineralogy in Yale College, Connecticut.	1860
	Elihu Loomis, Professor of Natural Philosophy, Yale College, Connecticut.	1860
10	Robert Lewis John Ellery, F.R.A.S., Victoria.	1874
	Sir John William Dawson, LL.D., F.R.S., Principal of McGill College, Montreal.	1883

BRITISH.

	James Prescott Joule, LL.D., D.C.L., F.R.S., Manchester.	1860
	Sir Andrew Crombie Ramsay, LL.D., F.R.S., London.	1874
	Sir Joseph Dalton Hooker, K.C.B., K.C.S.I., M.D., D.C.L., LL.D., F.R.S., Kew.	1874
14	Thomas Henry Huxley, Ph.D., LL.D., D.C.L., F.R.S., London.	1876
	Herbert Spencer, London.	1879
	John Tyndall, LL.D., D.C.L., F.R.S., M.R.I., London.	1880
	Rev. John Kerr, LL.D., Glasgow.	1885
	George Gabriel Stokes, M.A., LL.D., P.R.S., Cambridge.	1887

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

Rev. H. W. Crosskey, LL.D., F.G.S., 117 Gough road, Birmingham.	1874
A. S. Herschel, B.A., F.R.S., F.R.A.S., Professor of Physics, College of Science, 16 Saville row, Newcastle-on-Tyne.	1874
Thomas E. Thorpe, Ph.D., F.R.S., Royal School of Mines, London.	1874
John Aitken, F.R.S.E., Darroch, Falkirk.	1883
5 Alex. Buchan, M.A., LL.D., F.R.S.E., Secretary to the Scottish Meteorological Society, 73 Northumberland street, Edinburgh.	1883
James Dewar, M.A., F.R.S.S., L. & E., M.R.I., Jacksonian Professor of Physics, University of Cambridge, and Professor of Chemistry in the Royal Institution of Great Britain.	1883
Stevenson Macadam, Ph.D., F.R.S.E., Lecturer on Chemistry, Surgeons' Hall, Edinburgh.	1883
Joseph Swan, Newcastle-on-Tyne and London.	1883
E. A. Wünsch, F.G.S., London.	1883
10 George Anderson, Master of the Mint, Melbourne.	1885

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

* Denotes Life Members.

Ackroyd, J. E., 237 Gairbraid street, Maryhill.	1887	20 Bain, Sir James, F.R.S.E., 3 Park terrace.	1866
Adam, William, M.A., 415 Sauchie- hall street.	1876	Bain, Robert, 132 West Nile street.	1869
Addie, John, 144 St. Vincent street.	1861	Balloch, Robert, 131 St. Vincent street.	1843
Aikman, C. M., M.A., B.Sc., F.R.S.E., F.I.C., F.C.S., Lec- turer on Agricultural Chemistry, Technical College, 183 St. Vincent street.	1886	Balmain, Thos., 1 Kew terrace, Kelvinside.	1881
5 Alexander, D. M., 8 Royal Crescent, Crosshill.	1887	Barclay, James, 36 Windsor terrace.	1871
Alexander, Peter, M.A., 26 Smith street, Hillhead.	1885	25 Barlow, John, M.D., Lecturer on Physiology in Royal Infirmary School, 27 Elmbank crescent.	1880
Alexander, Thos., 8 Sardinia terrace.	1869	Baronsfeather, W. N., Rosebank, Mansewood, Pollokshaws.	1880
Alley, Stephen, Sentinel Works, Pol- madie road.	1884	Barrett, Francis Thornton, Mitchell Library.	1880
Alston, J. Carfrae, 9 Lorraine Gar- dens, Dowanhill.	1887	*Barr, James, C.E., I.M., 132 West Regent street.	1883
10 Anderson, Alexander, 157 Trongate.	1869	Barr, Thos., M.D., F.F.P.S.G., 7 Albany place.	1879
Anderson, James Hackston, Wardlaw- hill, Rutherglen.	1885	30 Bathgate, William, M.A., 13 West- bourne gardens.	1887
Anderson, John, 22 Ann street.	1884	Bayne, A. Malloch, 1 Hamilton ter- race, Partick.	1878
Anderson, Robert, jun., 22 Ann street.	1887	Beatson, George T., B.A. Cantab., M.D., 2 Royal crescent.	1881
*Anderson, T. M'Call, M.D., Professor of Clinical Medicine in the Uni- versity of Glasgow, 2 Woodside terrace.	1873	Begg, Wm., 636 Springfield road.	1883
15 Anderson, W. F. G., 47 Union street.	1878	*Beith, Gilbert, 7 Royal Bank place.	1881
Andrews, D. J. F., 140 Douglas street.	1887	35 Bell, Dugald, 27 Lansdowne cres.	1871
Arnot, James Craig, 162 St. Vincent street.	1869	*Bell, Henry, 5 Cornwall terrace, Regent's Park, London, N.W.	1876
Arrol, Walter, 16 Dixon street.	1869	Bell, James, 7 Marlborough terrace, Kelvinside.	1877
Arrol, William A., 16 Dixon street.	1869	Bennett, Robert J., 8 Holland place.	1883
		Binnie, J., 69 Bath street.	1877

- 40 Binnie, Robert, Ashbourne, Gourrock. 1881
 Black, Adam Elliot, C.A., F.C.S.,
 2 Hillsborough square, Bruce st.,
 Hillhead. 1880
 Black, D. Campbell, M.D., M.R.C.S.E.,
 50 Woodlands road. 1872
 Black, J. Albert, Dunera, Row. 1869
 Black, John, 16 Park terrace. 1869
 45 Black, Malcolm, M.B., C.M., 5 Can-
 zing place. 1880
 *Black, J. Alexander, 17 Stanhope
 street. 1881
 *Black, J. Robertson, 17 Stanhope
 street. 1881
 Blackie, Robert, 17 Stanhope st. 1847
 Blackie, W. G., Ph.D., LL.D.,
 F.R.G.S., 17 Stanhope street. 1841
 50 Blackie, Walter W., R.Sc., 1 Bel-
 haven terrace. 1886
 Blair, G. M. Lellan, 2 Lilybank
 terrace. 1869
 Blair, J. M. Lellan, 2 Rute Gardens,
 Hillhead. 1869
 Blair, Matthew, 11 Hampton Court
 terrace. 1887
 Blyth, James, M.A., F.R.S.E., Pro-
 fessor of Mathematics and Natural
 Philosophy in Anderson's College. 1881
 55 *Blyth, Robert, C.A., 1 Montgomerie
 quadrant. 1885
 Bost, Wm. David Ashton, Lang-
 roads, Paisley. 1884
 Bost, Timothy, 55 Renfield street. 1876
 Bottomley, James T., M.A., F.R.S.E.,
 F.C.S., Demonstrator in Natural
 Philosophy, University of Glas-
 gow, 13 University gardens, Hill-
 head. 1880
 Bottomley, Wm., C.E., University. 1880
 60 Boucher, J., I.A., 247 St. Vincent
 street. 1870
 Bowen, F. O., D.Sc., M.A., F.L.S.,
 Regius Professor of Botany in
 the University of Glasgow, 45
 Kersland terrace. 1885
 Bowie, Campbell T., 26 Bothwell
 street. 1870
 Boyd, John, Shettleston Iron-works,
 near Glasgow. 1873
 Boyd, Rev. William, LL.D., 6
 Park street, East. 1885
 65 Brand, James, C.E., 172 Buchanan st. 1880
 Brodie, John Kwan, M.D., C.M.,
 F.F.P.S.G., 1 Albany place. 1873
 Brownhead, Horatio K., I.A.,
 A.R.I.B.A., 245 St. Vincent st. 1870
 Brown, Alexander, 100 Bath street. 1887
 *Brown, Hugh, 5 St. John's terrace,
 Hillhead. 1887
 70 Brown, James, 70 St. Vincent st. 1876
 Brown, John, 22 Renfield street. 1879
 *Brown, John, 11 Somerset place. 1881
 Brown, John C., 149 West George
 street. 1880
 Brown, Richard, Strone Colliery Co.,
 49 W. George street. 1855
 75 Brown, Robert, 19 Jamaica street. 1882
 *Brown, Wm. Stevenson, 41 Oswald
 street. 1886
 Brown, William, 22 Westminster
 terrace. 1888
 Brownlee, J., 23 Burnbank gardens. 1860
 Brownlie, Archibald, Bank of Scot-
 land, Barrhead. 1880
 80 Brownlie, Jas., Victoria Saw Mills. 1877
 Brunton, Rev. Alex., Ardbeg villa,
 Craigpark, Dennistoun. 1884
 *Bryce, Charles C., 141 West George
 street. 1884
 Bryce, David, 129 Buchanan street. 1872
 *Bryce, Robert, 82 Oswald street. 1886
 85 *Buchan, Wm. P., S.E., 21 Renfrew
 street. 1875
 Buchanan, Alex. M., A.M., M.D.,
 Professor of Anatomy, Anderson's
 College Medical School, 98 St.
 George's road. 1876
 Buchanan, George, A.M., M.D.,
 Professor of Clinical Surgery in
 the University of Glasgow, 193
 Bath street. 1875
 Buchanan, George S., 85 Candle-
 riggs. 1845
 Buchanan, William L., 212 St.
 Vincent street. 1873
 90 *Buchanan, William, 10 Carrington
 street. 1886
 Burnet, John, I.A., 167 St. Vincent
 street. 1850
 Burnet, Lindsay, Assoc. M.I.C.E.,
 St. Kilda, Dowanhill. 1882
 Burns, J., M.D., 15 Fitzroy place,
 Sauchiehall street. 1864
 Burns, J. Cleland, 1 Park gardens. 1874
 95 Callajon, Ventura De, 2 Carlton
 terrace, Kelvinside. 1886
 Cameron, Charles, M.D., LL.D.,
 M.P., 104 Union street. 1870
 Cameron, H. C., M.D., 203 Bath
 street. 1873
 Cameron, R., 31 Westbourne grdns. 1873
 *Campbell, Sir A. C., Bart., M.P., of
 Blythwood, Renfrew. 1885
 100 Campbell, J. A., LL.D., M.P., 137
 Strathcathro, Brechin. 1848
 *Campbell, James, 137 Ingram st. 1885
 Campbell, John D., 4 Woodvale
 place, Copeland road, Govan. 1858
 Campbell, John MacNaught, Kelvin-
 grove Museum. 1885
 *Campbell, Louis, 3 Eton terrace,
 Hillhead. 1881
 105 Carlile, Thomas, 23 West Nile st. 1851

- Carmichael, Neil, M.D., C.M., 29 South Cumberland street. 1873
- Carrick, John, I.A., City Architect, 74 Hutcheson street. 1846
- Cassels, Robert, 168 St. Vincent street. 1858
- Cayzer, Charles W., 109 Hope st. 1886
- 110 Chalmers, James, I.A., 101 St. Vincent street. 1884
- Cherrie, James M., Clutha cottage, Tollcross. 1876
- Christie, James, A.M., M.D., F.F.P.S.G., 2 Great Kelvin terrace, Bank street, Hillhead. 1876
- Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
- Chrystal, W. J., F.I.C., F.C.S., Shawfield Works, Rutherglen. 1882
- 115 Church, W. R. M., C.A., 75 St. George's place. 1885
- Clapperton, Charles, 16 Lilybank gardens, Hillhead. 1882
- Clapperton, John, 5 Sandyford pl. 1874
- *Clark, G. W., Dumbreck house. 1877
- Clark, Henry E., F.F.P.S., M.R.C.S. Eng., 24 India street. 1876
- 120 Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
- Clark, John, 9 Wilton crescent. 1872
- *Clark, William, 125 Buchanan st. 1876
- Clavering, Thos., 27 St. Vincent place. 1856
- *Cleland, John, M.D., LL.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 1884
- 125 Clinkskill, James, 1 Holland place. 1868
- Clouston, Peter, 1 Park terrace. 1861
- Coats, Joseph, M.D., 31 Lynedoch street. 1873
- *Cochran, Robert, 7 Crown circus, Dowanhill. 1877
- Coghill, Wm. C., 263 Argyle street. 1873
- 130 Coleman, J. J., F.I.C., F.C.S., F.R.S.E., Ardarroch, Bearsden, Vice-President. 1869
- Collins, Sir William, F.R.G.S., 3 Park terrace, East. 1869
- Colquhoun, Jas., 158 St. Vincent st. 1876
- Colville, James, M.A., D.Sc., 15 Newton place. 1885
- Combe, William, 257 W. Campbell street. 1877
- 135 Connal, Sir Michael, Virginia buildings. 1848
- Connell, James, 182 Crookston st. 1870
- Connell, Wm., 38 St. Enoch square. 1870
- Cooke, Stephen, F.C.S., 85 Buccleuch street. 1886
- Copeland, Jas., Dundonald road, Kelvinside. 1869
- 140 Copland, Wm. R., M. Inst. C.E., 146 West Regent street. 1876
- Coubrough, A. Sykes, Blanehead, Strathblane. 1869
- Coulson, Arthur, 140 Douglas st. 1888
- Couper, James, Craigforth House, Stirling. 1862
- Cowan, David, Mount Gerald, Larchbert. 1888
- 145 Cowan, M'Taggart, C.E., 27 Ashton terrace, Hillhead. 1876
- Craig, Alexander T., 264 St. Vincent street. 1884
- Craig, T. A., C.A., 139 St. Vincent street. 1886
- Crawford, David, jun., Glengowan Print-works, Caldercruix, by Airdrie. 1873
- Crawford, Robert, 84 Miller st. 1886
- 150 Crawford, W. B., 104 W. Regent st. 1872
- Crawford, Wm. C., M.A., Lockharton gardens, Slateford, Edinburgh. 1869
- Cree, Thomas S., 21 Exchange sq. 1869
- Cross, Alexander, 14 Woodlands terrace. 1887
- Cruikshank, George M., 62 St. Vincent street. 1885
- 155 Cumming, Thos., 31 Huntly grdns. 1888
- Cunningham, John M., 18 Woodside terrace. 1881
- Cunningham, J. R., jun., 15 Windsor circus, Kelvinside. 1881
- Curphey, Wm. Salvador, 268 Renfrew street. 1883
- Cuthbert, Alexander A., 14 Newton terrace. 1885
- 160* Cuthbertson, Sir John N., 29 Bath street. 1850
- Danaken, A. B., 179 West George street. 1877
- *Dansen, John, I.M., 121 West Regent street. 1876
- Darling, Geo. E., 178 St. Vincent street. 1870
- Davidson, John, 51 Grant street. 1885
- 165 Day, St. John Vincent, C.E., F.R.S.E., 115 St. Vincent street. 1866
- Deas, Jas., C.E., 7 Crown gardens, Dowanhill. 1869
- Dempster, John, Cambridge terrace, Albert Road, Pollokshields. 1875
- Dennison, William, C.E., 175 Hope street. 1876
- Dewar, Duncan, St. Fillans, West Coates, Cambuslang. 1877
- 170* Dick, George Handasyde, 136 Buchanan street. 1887
- Dittmar, W., LL.D., F.R.S.S., L. & E., Professor of Chemistry, Anderson's College. 1875
- *Dixon, A. Dow, 10 Montgomerie crescent, Kelvinside. 1873

- Dixon, Edward M., B.Sc., 11 Hope-
town place. 1860
- Dobbie, A. B., M.A., University. 1885
- 175 Donald, John, Dennistoun Public
School. 1872
- Donald, William J. A., 27 St. Vincent
place. 1877
- Donald, Alex. W., Bank place,
Cambuslang. 1880
- Dougall, Franc Gibb, 167 Canning
street. 1875
- Dougall, John, M.D., C.M.,
F.F.P.S.G., Lecturer on Materia
Medica, Royal Infirmary School
of Medicine, 6 Belmar terrace,
Pollokshields. 1876
- 180 Douglas, Campbell, I.A., 266 St.
Vincent street. 1870
- Downie, R. M., 95 Bath street. 1883
- Downie, Robert, jun., Carnytne
Dye-works, Parkhead. 1872
- Downie, Thomas, Hydepark
Foundry. 1886
- Drew, Alex., 175 West George
street. 1869
- 185 Duncan, Eben., M.D., C.M.,
F.F.P.S.G., 4 Royal crescent,
Crosshill. 1873
- Duncan, Robert, Engineer, Partick
Foundry. 1875
- Duncan, Robert, Shipbuilder, Port-
Glasgow. 1887
- *Duncan, Walter, 9 Montgomerie
crescent. 1881
- Dunlop, E. D., 40 W. Nile street. 1883
- 100* Dunlop, Nathaniel, 1 Montgomerie
crescent, Great Western road. 1870
- Dunn, Robert Hunter, 4 Belmont
crescent. 1878
- Dyer, Henry, M.A., C.E., 8 High-
burgh terrace, Dowanhill. 1883
- Dyer, Rev. John Joseph, 10 Hill
street, Springburn. 1885
- Eadie, Alexander, 250 Cathcart
road. 1885
- 105 Easton, Walter, 125 Buchanan st. 1878
- Nashon, William J., 150 West Regent
street. 1876
- Kidwards, John, Govanhaugh Dye-
works. 1883
- Kidwards, Matthew, 209 Sanchiehall
street. 1887
- Kider, James, C.E., 204 St. Vincent
street. 1881
- 110 Kicar, Francis, LL.D., Admiralty,
London. 1884
- *Kilns, T. Leonard, North British
Iron-works, Coatbridge. 1888
- Kilns, M.A., M.B., L.F.P.S.,
1 street. 1886
- Kilns, 7 Royal Bank place. 1883
- Fairweather, Wallace, C.E., 62 St.
Vincent street. 1880
- 205 Falconer, Patrick, 33 Hayburn cres-
cent, Partick. 1876
- Falconer, Thos., 50 Kelvingrove st. 1880
- Farquhar, John, 13 Belhaven terrace. 1872
- Fawcitt, Charles A., 4 Maule terrace,
Partick. 1879
- Fergus, Freeland, M.B., F.F.P.S.G.,
191 Bath street. 1887
- 210 Fergus, Jas., 5 Burnbank gardens. 1880
- *Ferguson, John, M.A., LL.D., Pro-
fessor of Chemistry, University of
Glasgow. 1869
- Ferguson, Peter, 15 Bute gardens,
Hillhead. 1866
- Ferguson, Thomas, Westmuir st.,
Parkhead. 1883
- Fergusson, Alex. A., 48 M'Alpine
street. 1847
- 215 Fernau, Paul, 6 Broomhill Avenue,
Partick. 1887
- Fife, William, 52 Glasford street. 1880
- Finlay, H. G., 16 Westbourne ter. 1888
- Finlay, Joseph, Clairmont, Winton
drive, Kelvinside. 1873
- Finlay, Robert Gilchrist, jun.,
Holmfield, Dalmuir. 1881
- 220 Finlayson, James, M.D., 2 Wood-
side place. 1873
- *Fleming, James, 136 Glebe street. 1880
- *Fleming, William James, M.D., 155
Bath street. 1876
- Foulis, William, C.E., 42 Virginia
street. 1870
- *Fowler, John, Kelvinbank terrace,
Sandyford. 1880
- 225 Frame, James, Union Bank of Scot-
land, 113 King street, Tradeston. 1885
- Fraser, Matthew P., 91 W. Regent
street. 1887
- Fraser, Robert, 2 Crown gardens,
Dowanhill. 1885
- Fraser, Daniel, 127 Buchanan st. 1853
- Frew, Alex., C.E., 175 Hope street. 1876
- 230 Fullarton, J. H., M.A., B.Sc.,
Natural History Department,
University. 1886
- Fyfe, Peter, 1 Montrose street. 1886
- Gairdner, Charles, Broom, Newton-
Mearns. 1884
- Gairdner, C. D., C.A., 115 St. Vin-
cent street. 1886
- Gairdner, W. T., M.D., LL.D., Pro-
fessor of Practice of Medicine in
the University of Glasgow, 225 St.
Vincent street. 1863
- 235 Gale, Jas. M., C.E., Water Office,
23 Miller street. 1856
- Galloway, T. Lindsay, C.E., 43 Mair
street, Plantation. 1881

- Galt, Alex., B.Sc., F.R.S.E., F.C.S.,
9 Park place, Rutherglen. 1887
- Gardner, Daniel, 36 Jamaica street. 1869
- *Garraway, John, 694 Duke st 1875
- 240 Geddes, Wm., Battlefield, Langside. 1846
- Gibb, Peter, 10 Granby terrace. 1883
- Gillespie, Edward, Chapel Croft,
Cambuslang. 1882
- Gillies, W. D., 2 Royal Exchange
court. 1872
- Gilfillan, Wm., 129 St. Vincent st. 1881
- 245 Glaister, John, M.B., 4 Grafton place. 1879
- Goldie, James, 40 St. Enoch square. 1883
- Goodwin, Robert, 58 Renfield st. 1875
- Gourlay, John, C.A., 24 George sq. 1874
- Gourlay, Robert, Kirklee avenue,
Great Western road. 1869
- 250 Gow, Leonard, jun., 19 Waterloo
street. 1884
- Gow, Robert, Cairndowan, Dowan-
hill gardens. 1860
- Graham, Alex. M., 20 Dixon street. 1887
- Graham, David, jun., 140 Douglas
street. 1876
- Graham, Robert, 61 Eglinton street. 1888
- 255 Graham, William, 195 Bath street. 1885
- *Grant, Robt., M.A., LL.D., F.R.S.,
Professor of Astronomy in the Uni-
versity of Glasgow, Observatory,
Hon. Vice-President. 1860
- Gray, James, M.D., 15 Newton
terrace. 1863
- Gray, James, 2 Balmoral crescent,
Crosshill. 1876
- Gray, Thomas, B.Sc., F.R.S.E.,
Physical Laboratory, University, 1887
- 260 Greenlees, Alex., M.D., 33 Elm-
bank street. 1864
- Grierson, James, 5 Belhaven cres.,
Kelvinside. 1880
- Grieve, John, M.A., M.D., F.R.S.E.,
care of W. L. Buchanan, 212 St.
Vincent st. 1856
- Griffiths, Azariah, Elmbank, Fal-
kirk. 1886
- Guild, J. Wyllie, C.A., 17 Park
terrace. 1884
- 265 Haldane, T. Fred., Cartvale Chemi-
cal Works, Paisley. 1884
- Hamilton, Andrew, 2 Belmar ter-
race, Pollokshields. 1884
- Hamilton, George, 149 St. Vincent
street. 1871
- Hamilton, John, I.A., 212 St. Vin-
cent street. 1885
- Hamilton, Patrick, 149 St. Vincent
street. 1854
- 270 Hamilton, David C., 21 Carlton
place. 1880
- Hannay, Anthony, 25 Exchange
square. 1856
- Hannay, Jas. B., F.R.S.E., F.C.S.,
67 Great Clyde street. 1879
- Hannay, Maxwell, 104 West George
street. 1881
- Hart, Arthur, 20 Woodlands ter-
race. 1883
- 275*Harvie, John, Secretary, Clydesdale
Bank, 30 St. Vincent place. 1880
- Harvie, William, 222 Broomielaw, 1888
- *Henderson, A. P., 10 Crown terrace,
Dowanhill. 1880
- Henderson, George G., B.Sc., Chemi-
cal Laboratory, University. 1883
- *Henderson, John, jun., 4 Crown
terrace, Dowanhill. 1879
- 280 Henderson, Robert, 27 Union st. 1885
- Henderson, Thos., 47 Union street. 1855
- Henderson, Wm., Ennerdale, Win-
ton drive, Kelvinside. 1853
- *Henderson, Wm., 15 Cadogan st. 1873
- Henry, R. W., 8 Belhaven cres. 1875
- 285 Heys, Zechariah J., South Arthurlie,
Barrhead. 1870
- Higginbotham, James S., Spring-
field court, Queen street. 1874
- Higginbotham, Robert Ker, 10 Great
Hamilton street. 1885
- Higgins, Henry, jun., 252 West
George street. 1878
- Hodge, William, 27 Montgomery
drive, Kelvinside. 1878
- 290 Hoey, David G., 8 Gordon street. 1869
- Hogg, Robert, Inglisby villa, Pollok-
shields. 1865
- Holt, T. G., 25 Wellington street. 1875
- Honeyman, John, F.R.I.B.A., 140
Bath street. 1870
- Horne, R. R., C.E., 150 Hope
street. 1876
- 295 Howat, William, 37 Elliot street. 1885
- Howatt, James, I.M., 146 Buchanan
street. 1870
- Howatt, William, I.M., 146
Buchanan street. 1870
- Hudson, John G., 18 Aytoun road,
Pollokshields. 1883
- Hunt, Edmund, 87 St. Vincent
street. 1856
- 300*Hunt, John, Milton of Campsie. 1881
- *Jack, William, M.A., LL.D., Pro-
fessor of Mathematics in the Uni-
versity of Glasgow. 1881
- Jackson, William V., 237 Ingram
street. 1888
- Jamieson, Andrew, F.R.S.E.,
A.M.I.C.E., M.S.T.E., &c.,
38 Bath street. 1881
- Johnson, James Yate, C.E., 115 St.
Vincent street. 1883
- 305 Johnstone, Jas., Coatbridge street,
Port-Dundas. 1866

- Kay, Wm. F., Printworks, Thorn-
hobank. 1887
- Kean, James, 96 Thistle street,
Garnethill. 1888
- Kennedy, Hugh, Redclyffe, Partick. 1876
- Kennedy, William, St. Margaret's,
Newark drive, Pollokshields. 1882
- 310 Ker, Charles, M.A., C.A., 1 Windsor
terrace, west. 1885
- *Ker, Wm., 1 Windsor ter., west. 1874
- Kerr, Adam, 175 Trongate. 1887
- Kerr, Charles James, Greenfaulds
house, Cumbernauld. 1877
- Kerr, James Hy., 13 Virginia st. 1872
- 315 Kerr, John G., M.A., 16 Grafton
street. 1878
- Kay, William, Tradeston Gas-works. 1877
- King, James, 57 Hamilton drive,
Hillhead. 1848
- King, Mr James, Bart., LL.D., of
Leverholm, 115 Wellington st. 1855
- Kirk, Alexander C., LL.D., 19
Athole gardens, Dowanhill. 1869
- 320 Kirk, Robert, M.D., Newton cot-
tage, Partick. 1877
- Kirkpatrick, Alexander B., 24 Ber-
keley terrace. 1885
- Kirkpatrick, Andrew J., 179 West
George street. 1869
- Kirkwood, Anderson, LL.D., 7
Melville terrace, Stirling. 1869
- Knox, Adam, 47 Crownpoint road. 1881
- 325 Knox, John, 120 West George
street. 1870
- Knox, John, 151 Renfrew street. 1883
- Lathlaw, John, 35 Hope street. 1885
- Latt, George H., 150 Greenhead
street. 1882
- Latt, John, Marchmont, Port-
Glasgow. 1876
- 330 Latt, John, Royal Exchange Sale
Rooms. 1879
- Laudy, Thomas, 220 Parliamentary
road. 1870
- Lang, William, jun., F.C.S., Cross-
park, Partick. 1865
- Latta, James, 8 Miller street. 1860
- Latta, John, 138 West George
street. 1880
- 335 Lacombe, Rev. Albert, 50 Prince's
square, Strathbungo. 1885
- Letch, Alexander, 100 Rosebank
terrace, Leam street. 1886
- Leister, William, 2 Doune terrace,
N. Woodside. 1884
- Leister, W. R., M.F.C., 2 Doune
terrace, N. Woodside. 1884
- *Lindsay, David M., M.A., 80 West
street. 1882
- Low, James, 176 St. Vincent
street. 1878
- Livingston, Robert, 263 Argyle
street. 1879
- Lochore, John, 8 Bellahouston ter.,
Ibrox. 1886
- *Long, John Jex, 11 Doune terrace,
Kelvinside. 1862
- Lothian, J. Alexander, M.D.,
L.R.C.S.E., 6 Newton terrace. 1872
- 345 Low, James, 176 St. Vincent st. 1878
- M'Andrew, John, 17 Park Circus
place. 1843
- M'Ara, Alex., 65 Morrison street. 1888
- M'Callum, James Thyne, 83 St.
Vincent street. 1887
- Macarthur, J. G., Clutha Bank,
Kilmalcolm. 1874
- 350 Maccall, Samuel, 16 Hillsborough
square, Hillhead. 1882
- *M'Calland, Andrew Simpson, C.A.,
4 Crown gardens, Dowanhill. 1884
- M'Conville, John, M.D., 27 Newton
place. 1870
- M'Crae, John, 7 Kirklee gardens,
Maryhill. 1876
- M'Creath, James, M.E., 208 St.
Vincent street. 1874
- 355 Macdonald, Arch. G., 8 Park circus. 1869
- Macdonald, Thomas, 109 Bath st. 1869
- M'Farlane, Graham Jas., Elderslie. 1882
- Macfarlane, Samuel, Meadowbank,
Torrance of Campsie. 1876
- M'Farlane, Walter, Printworks,
Thornliebank. 1869
- 360 Macfarlane, Walter, 12 Lynedoch
crescent. 1885
- M'Farlane, Wm., Edina Lodge,
Rutherglen. 1888
- M'Gillivray, James P., 209 West
Campbell street. 1883
- *M'Gillivray, R. A., 129 West Regent
street. 1880
- M'Gregor, Duncan, F.R.G.S., 37
Clyde place. 1867
- 365 M'Gregor, James, 1 East India
avenue, London, E.C. 1872
- M'Grigor, Alexander B., LL.D.,
172 St. Vincent street. 1857
- *M'Ilwraith, James, 4 Westbourne
terrace, Kelvinside. 1872
- Macindoe, William L., M.A., LL.B.,
32 Westbourne gardens. 1885
- M'Intyre, Wm., Marion Bank,
Rutherglen. 1888
- 370 M'Ivor, R. W. Emerson, F.L.C.,
F.C.S., 67 Great Clyde street. 1886
- Mackay, John Yule, M.D., 34 Elm-
bank crescent. 1885
- Mackay, John, jun., 354 Sauchie-
hall street. 1869
- *McKenzie, W. D., 43 Howard
street. 1875

- *M'Kenzie, W. J., 197 Dumbarton road. 1879
- 375 *M'Kendrick, John G., M.D., C.M., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of Institutes of Medicine in the University of Glasgow, 45 Westbourne gardens, *Vice-President*. 1877
- Mackinlay, David, 6 Great Western terrace, Hillhead. 1855
- Mackinlay, James Murray, 4 Westbourne gardens. 1886
- Mackinlay, Wm., 4 Bothwell terrace, Hillhead. 1887
- M'Kissack, John, 234 W. George street. 1881
- 380 M'Lachlan, D., 15 Hill street, Garnethill. 1885
- MacLae, A. Crum, 147 St. Vincent street. 1884
- MacLean, Walter, 2 Bothwell cir. 1887
- M'Laren, Robert, Canal street, Port-Eglinton. 1848
- *MacLay, David T., 169 W. George street. 1879
- 385 Maclean, A. H., 8 Hughenden terrace, Kelvinside. 1870
- Maclean, Magnus, M.A., 21 Hayburn crescent, Partickhill. 1885
- MacLehose, James J., M.A., 61 St. Vincent street. 1882
- M'Lellan, Walter, 129 Trongate. 1856
- M'Lennan, James, 40 St. Andrew's street. 1888
- 390 M'Nab, John, 69 St. Vincent street. 1881
- M'Naughton, Duncan, Bearaden. 1883
- Macouat, B. R., 37 Elliot street 1885
- Macphail, Donald, M.D., Garturk cottage, Whifflet, Coatbridge. 1877
- M'Pherson, George L., 26 Albert road, Crosshill. 1872
- 395 M'Vail, D. C., M.B., 3 St. James' terrace, Hillhead. 1873
- Machell, Thomas, 39 Great Western road. 1886
- Main, Robert B., Milverton, Dalziel Drive, Pollokshields. 1885
- Mann, John, C.A., 188 St. Vincent street, *Treasurer*. 1856
- Mann, John, jun., M.A., C.A., 188 St. Vincent street. 1885
- 400 Manwell, James, The Hut, 4 Albert road, Pollokshields. 1876
- Marwick, Sir J. D., LL.D., F.R.S.E., Killermont House, Maryhill. 1878
- Marks, Samuel, Jeanette villa, Tollcross. 1884
- *Mason, Stephen, M.P., 24 Belhaven terrace. 1870
- Mathieson, Thomas A., 13 East Campbell street. 1869
- 405 Mavor, Henry A., 140 Douglas st. 1887
- Mavor, James, 134 St. Vincent street. 1885
- Mayer, John, 11 Balmoral crescent, Crosshill, *Secretary*. 1860
- Mechan, Arthur, 60 Elliot street. 1876
- Mechan, Henry, 60 Elliot street. 1879
- 410 Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
- Menzies, Thos. J., M.A., B.Sc., F.C.S., Stranraer Academy, Stranraer. 1887
- Michaelson, M., 5 Woodside place. 1878
- Middleton, Robert T., 179 West George street. 1860
- Millar, James, 158 Parliamentary road. 1870
- 415 Miller, A. Lindsay, 121 W. Regent street. 1878
- *Miller, Arch. Russell, The Cairns, Cambuslang. 1884
- Miller, David S., 1 Royal ter., W. 1887
- *Miller, George, Winton drive, Kelvinside. 1881
- Miller, George, M.D., 1 Ibrox ter., Paisley road. 1885
- 420 Miller, G. J., Frankfield, Shettleston. 1888
- Miller, John (Messrs. James Black & Co.), 23 Royal Exchange sq. 1874
- Miller, Richard, 54 St. Enoch square. 1885
- Miller, Thomas, 138 Wellington st. 1882
- *Miller, Thos. P., Cambuslang Dyeworks. 1864
- 425 Miller, W. M., 7 Mansfield place, West Regent street. 1867
- Mills, Edmund J., D.Sc., F.R.S., Anderson's College. 1875
- Milne, William, M.A., B.Sc., F.R.S.E., High School. 1881
- Mirrlees, James B., Redlands, Kelvinside. 1869
- Mitchell, George A., 67 West Nile street. 1883
- 430 Mitchell, Jas. L., 10 Gt. Western terrace. 1878
- Mitchell, Robert, 12 Wilson street, Hillhead. 1870
- *Moffatt, Alexander, 47 Union st. 1874
- Moir, Charles S., 92 Union street. 1884
- *Monteith, Robert, Greenbank, Dowanhill gardens. 1885
- 435 Moore, Alexander, C.A., 209 West George street. 1869
- Moore, Alexander George, M.A., B.Sc., 13 Clairmont gardens. 1886
- Morgan, John, Springfield house, Bishopbriggs. 1844
- Morrice, Jas. A., Tullymet, Aytoun road, Pollokshields. 1883
- Morrison, James, 98 Sauchiehall street. 1869

- 440 Morton, James, M.D., Professor of
Materia Medica in Anderson's
College, 199 Bath street, *Vice-*
President. 1868
- Mossman, John, 6 Queen's terrace,
West. 1870
- Motion, James Russell, 38 Coch-
rane street. 1887
- Muir, Alex., 65 Eglinton street. 1883
- *Muir, Allan, 36 George street. 1881
- 445 Muir, James, C.A., 149 West George
street. 1887
- Muir, John, 6 Park gardens. 1876
- Muir, Thomas, M.A., LL.D.,
F.R.S.E., Beechcroft, Bothwell. 1874
- *Muirhead, Andrew Erskine, Cart
Forge, Crossmyloof. 1873
- *Muirhead, Henry, M.D., LL.D.,
F.F.P.S.G., Bushy Hill, Cambus-
lang, *Hon. Vice-President.* 1866
- 450 Muirhead, James, 10 Doune gardens,
Kelvinside. 1887
- *Muirhead, Robert F., M.A., B.Sc.,
Rochester House, Ealing, Lon-
don, W. 1879
- Munro, Daniel, 22 Burnbank ter. 1867
- Munsie, George, 1 St. John's ter.,
Hillhead. 1871
- Munsie, Robert George, 10 Berke-
ley terrace, West. 1883
- 455 Murdoch, Jas. B., 18 Bridge street, 1855
- Murdoch, Robert, 10 King st., S.S. 1880
- Murdoch, William, 20 Carlton
place. 1879
- *Murray, David, 169 West George st. 1876
- Murray, A. Erskine, Sheriff-Sub-
stitute of Lanarkshire, Sundown,
Montgomerie drive. 1881
- 460 Napier, Alex., M.D., F.F.P.S.G.,
3 Royal terrace, Crosshill. 1886
- Napier, James, jun., 10 Carment
drive, Shawlands. 1870
- *Napier, John, 23 Portman square,
London. 1846
- Neilson, Walter M., Queenshill,
Ringford, Kirkcudbrightshire. 1843
- Nelson, Alex., 80 Gordon street. 1880
- 465 Nelson, D. M., 164 St. Vincent st. 1875
- *Newlands, Joseph F., 28 Renfield
street. 1883
- Newman, David, M.D., C.M., Path-
ologist, Royal Infirmary, 18 Wood-
side place, W. 1877
- Nicol, James, City Chambers, 1872
- Nicholson, Alex., jun., 6 Annfield
place, Dennistoun. 1883
- 470 Niven, Thos. O., C.E., 131 West
Regent street. 1884
- Nowery, William, 37 Derby street. 1876
- Ogilvie, William, 1 Doune terrace. 1881
- Osborne, Alex., 5 Oakley terrace,
Dennistoun. 1870
- Outram, D. E., 16 Grosvenor ter.,
Hillhead. 1878
- 475 Park, James, Millburn Chemical
Works. 1877
- *Parnie, James, 32 Lynedoch street. 1874
- Paterson, John, 522 Pollokshaws
road. 1888
- *Paterson, Robert, C.A., 28 Renfield
street. 1881
- Paton, Jas., F.L.S., Corporation Gal-
leries, and Kelvingrove Museum. 1876
- 480 Paton, William Grant, 43 Mulgrave
street, Prince's park, Liverpool. 1883
- Patterson, T. L., F.C.S., at John
Walker & Co.'s, Greenock. 1873
- Pearce, Sir William, Bart., M.P.,
10 Park terrace. 1881
- Petrie, Alexander, I.A., 111 Bath
street. 1885
- Pirie, John, M.D., 26 Elmbank
crescent. 1877
- 485*Pirrie, Robert, 9 Buckingham ter. 1875
- Pollock, Arthur, Dillichip Works,
Alexandria. 1879
- *Pollock, R., M.B., C.M., F.F.P. & S.G.,
Laurieston house, Pollokshields. 1883
- Poynter, John E., 72 Great Clyde
street. 1866
- Price, Rees, L.D.S., Eng., 163 Bath
street. 1883
- 490 Pride, David, M.D., Townhead
House, Neilston. 1887
- *Provan, James, 40 West Nile st. 1868
- Provand, A. D., M.P., 8 Bridge
street, London, S.W. 1888
- Raalte, Jacques Van, 136 West
Regent street. 1884
- Ramsay, John, of Kildalton, 5
Dixon street. 1856
- 495 Ramsay, Robert, M.D., L.R.C.S.E.,
Lochwinnoch. 1881
- Rankine, David, C.E., 75 West Nile
street. 1875
- Rankine, Captain John, 31 Airlie
terrace, Pollokshields. 1869
- Rattray, Rev. Alex., M.A., Park-
head parish, 4 Westercraigs, Den-
nistoun. 1879
- Reid, Andrew, 20 North Albion st. 1875
- 500 Reid, David, 209 Sauchiehall street, 1887
- *Reid, Hugh, 10 Woodside terrace. 1880
- Reid, James, 10 Woodside terrace. 1870
- Reid, J. G., 9 St. Vincent place. 1874
- Reid, Thos., M.D., 11 Elmbank
street. 1869
- 505 Reid, William, M.A., High School. 1881
- *Reid, William L., M.D., 7 Royal
crescent, West. 1882

- Reith, Rev. George, M.A., Free College Church, 37 Lynedoch st. 1876
 Rennie, John, 87 Park road. 1886
 Renton, James Crawford, M.D., L.R.C.P.&S.Ed., 2 Buckingham terrace. 1875
 510 Richmond, Thos., L.R.C.P.E., 26 Burnbank terrace. 1887
 Ritchie, R. Brown, 79 West Regent street. 1883
 Ritchie, Wm., jun., Waltry, Milton of Campsie. 1870
 Robertson, Archibald, 25 Queen st. 1863
 Robertson, Archibald, 12 Hope st. 1867
 515 Robertson, Archibald, Ballanclerach, Lennoxton. 1884
 Robertson, Rev. James, D.D., Professor of Oriental Languages in the University of Glasgow. 1884
 Robertson, John, 10 Valeview ter., Langside, *Librarian*. 1860
 Robertson, J. M'Gregor, M.A., M.B., Muirhead Demonstrator of Physiology, University. 1881
 Robertson, Robert, Coplawhill, Pollokshaws road. 1877
 520 Robertson, Robert A., Nenthorne, 42 Aytoun road, Pollokshields. 1877
 Robertson, Robert H., Clyde Bank, Rutherglen. 1888
 Robertson, William, C.E., 123 St. Vincent street. 1869
 Robson, Hazelton R., 14 Royal crescent, West. 1876
 Rogers, John C., 163 W. George st. 1888
 525 Rose, Alexander, 18 Huntly gardens, Dowanhill. 1879
 Ross, Henry, 7 Park quadrant. 1876
 *Ross, John, 9 Westbourne gardens. 1885
 Rottenburg, Paul, 21 St. Vincent pl. 1872
 Rowan, David, 22 Woodside place. 1863
 530 Rowan, Frederick J., C.E., 121 West Regent street. 1882
 Rowan, W. G., 234 West George st. 1881
 Rundell, R. Cooper, Underwriters' Room, Royal Exchange. 1877
 Russell, James B., B.A., M.D., LL.D., 3 Foremount terrace, Partick, *President*. 1862
 Russell, Thomas, Clevedon, Kelvin-side gardens. 1870
 535 Salmon, W. Forrest, F.R.I.B.A., 197 St. Vincent street. 1870
 Schmidt, Alfred, 492 New City road. 1881
 Scott, Alex., 2 Lawrence place, Dowanhill. 1871
 Scott, Arthur T., M.A., 6 Wilton crescent. 1882
 *Scott, D. M'Laren, Braidfaulds avenue, Tollcross. 1881
 540 Scott, Robt., I.M., 115 Wellington street. 1884
 Seligmann, Hermann L., 135 Buchanan street. 1850
 Sellars, Jas., I.A., 266 St. Vincent street. 1873
 Shaw, John M., 14 Union street. 1880
 Sheriff, John, 156 St. Vincent st. 1876
 545 Sim, William, 3 Royal crescent. 1862
 Simons, Michael, 206 Bath street. 1880
 Simpson, P. A., M.A. Cantab., M.D., Regius Professor of Forensic Medicine, University, 1 Blythswood square. 1881
 Sinclair, Alexander, Ajmere lodge, Langside. 1883
 Sinclair, D., National Telephone Co., Limited, 8a Royal Exchange buildings. 1883
 550 Smart, William, M.A., Nunholm, Dowanhill. 1886
 Smellie, George, I.M., 167 St. Vincent street. 1880
 *Smellie, Thos. D., 209 St. Vincent street. 1871
 Smith, D. Johnstone, C.A., 149 W. George street. 1888
 Smith, Francis, 45 Gordon street. 1875
 555 Smith, Harry J., Ph.D., Coltness Iron-works, Newmains. 1877
 Smith, Hugh C., 55 Bath street. 1861
 *Smith, J. Guthrie, 54 West Nile street. 1875
 *Smith, Robert B., Bonnybridge, Stirlingshire. 1884
 Smith, W. R. W., 6 S. Hanover st. 1868
 560 Somerville, David, 35 King street, S.S. 1885
 Sorley, Robert, 3 Buchanan st. 1878
 Spens, John A., 169 W. George st. 1879
 Spiers, John, 43 Great Western road, Hillhead. 1885
 Stanford, Edward C. C., F.C.S., Glenwood, Dalmuir, Dumbarton-shire. 1864
 565 *Stephen, John, Domira, Partick. 1880
 Stephen, Robt. R., Adelphi Biscuit Factory. 1867
 *Steven, Hugh, Westmount, Montgomerie drive. 1869
 Steven, John, 32 Elliot street. 1875
 Stevenson, Allan, 42 Newmarket street, Ayr. 1886
 570 *Stevenson, Jas., F.R.G.S., 23 West Nile street. 1870
 Stevenson, John, C.E., 208 St. Vincent street. 1885
 Stevenson, William, Tower Bank, Lenzie. 1870
 Stevenson, Wm., 21 Clyde place. 1888
 Stewart, Andrew, Jordanhill house. 1887
 575 Stewart, David, 3 Clifton place. 1856

- Stewart, James, 41 Oswald street. 1887
 Stewart, James Reid, 30 Oswald st. 1845
 Stewart, John, Western Saw Mills. 1877
 Stuart, J. Watson, 88 St. Vincent street. 1881
 580 Stirton, James, M.D., F.L.S., 5 Newton terrace. 1876
 Stobo, Thomas, Somerset House, Garelochhead. 1884
 Stoddart, James Edward, 60 Robertson street. 1872
 Storer, James, 48 French street, Bridgeton. 1875
 Strain, John, C.E., 154 West George street. 1876
 585* Sutherland, David, Great Western Hotel, Oban. 1880
 *Sutherland, John, Great Western Hotel, Oban. 1880
 Sutherland, J. R., 5 Westercraigs, Dennistoun. 1884
 Sutherland, Thos., 198 Parliamentary road. 1886
 Swanston, John, 47 Melville street, Pollokshields. 1872
 590 Tatlock, John, F.I.C., 100 Sauchiehall street. 1875
 Tatlock, Robt. R., F.R.S.E., F.I.C., F.C.S., 138 Bath street. 1868
 Taylor, Benjamin, 10 Derby cres., Kelvinside. 1872
 Teacher, Adam, 14 St. Enoch sq. 1868
 Tennant, Sir Charles, Bart., 217 West George street. 1868
 595 Tennant, Gavin P., M.D., 159 Bath street. 1875
 Terrace, David, Dawsholm Gasworks, Maryhill. 1883
 Thomson, David, I.A., F.R.I.B.A., 116 St. Vincent street. 1869
 Thomson, George C., F.C.S., 39 Kersland terrace. 1883
 Thomson, Gilbert, M.A., C.E., 75 Bath street. 1885
 600 Thomson, Graham Hardie, 10 Doune terrace, North Woodside. 1869
 *Thomson, James, F.R.I.B.A., 88 Bath street. 1886
 Thomson, James, F.G.S., 3 Abbotsford place. 1863
 Thomson, Jas., LL.D., F.R.S., C.E., Professor of Engineering in the University of Glasgow, 2 Florentine Gardens, Hillhead. 1874
 Thomson, Jonathan, 136 W. George street. 1869
 605 Thomson, Sir William, LL.D., D.C.L., F.R.S.S., L. & E., Professor of Natural Philosophy, University of Glasgow, *Hon. Vice-President.* 1846
 Townsend, Joseph, 19 Crawford st., Port-Dundas. 1856
 *Tullis, James Thomson, Anchorage, Burnside, Rutherglen. 1883
 Turnbull, John, 37 West George st. 1843
 *Turnbull, John, jun., M.I.M.E., 255 Bath street. 1883
 610 Turner, George A., M.D., 1 Clifton place, Sauchiehall street. 1883
 Turner, William, 33 Renfield st. 1875
 Underwood, Francis H., LL.D., 107 West Regent street. 1886
 Ure, John, Crown Mills, 68 Washington street. 1856
 Urie, John, 83 Jamaica street. 1876
 615 Verel, Wm. A., The Linn, Cathcart. 1883
 Walker, Adam, 35 Elmbank cres. 1880
 *Walker, Archibald, B.A. (Oxon.), F.C.S., 8 Crown ter., Dowanhill. 1885
 Walker, James A., 112 St. Vincent street. 1884
 Walker, Malcolm M'N., F.R.A.S., 45 Clyde place. 1853
 620 Wallace, Abraham, M.D., 4 Newton place. 1877
 *Wallace, Hugh, 30 Havelock street. 1879
 Wallace, Wm., Ph.D., F.R.S.E., F.I.C., F.C.S., 138 Bath street, *Hon. Vice-President.* 1851
 Wallace, Wm., M.A., M.B., C.M., Westfield House, Shawlands. 1888
 Wardlaw, Johnston, 83 Taylor st. 1884
 625 Warren, John A., 115 Wellington st. 1887
 Watson, Archibald, 29 Elmbank crescent. 1881
 Watson, James, Cluniter, Innellan. 1873
 Watson, John, 205 West George street. 1886
 Watson, Joseph, 225 West George street. 1882
 630* Watson, Thomas Lennox, I.A., F.R.I.B.A., 108 W. Regent st. 1876
 *Watson, William Renny, 16 Woodlands terrace. 1870
 Welsh, Thos. M., 51 St. Vincent crescent. 1883
 Wenley, James A., Bank of Scotland, Edinburgh. 1870
 Westlands, Robert, 99 Mitchell st. 1869
 635 White, John, Scotstoun mills, Partick. 1875
 Whitelaw, Alexander, 87 Sydney street. 1855
 *Whitson, Jas., M.D., F.F.P. & S.G., 13 Somerset place. 1882
 Whytlaw, Robert A., 1 Windsor quadrant, Kelvinside. 1885
 Whytlaw, R. A., jun., 1 Windsor quadrant, Kelvinside. 1884

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|------|--------------------------------------|------|------------------------------------|------|
| 640 | Widmer, Justus, 21 Athole gardens. | 1887 | Woodburn, W. S., L.D.S., Lecturer | |
| | Williamson, John, 65 West Regent | | on Mechanical Dentistry, Ander- | |
| | street. | 1881 | son's College, 17 Carlton place. | 1881 |
| | Wilson, Alex., Hydepark Foundry, | | Wyper, James, 4 Queen Margaret | |
| | 54 Finnieston street. | 1874 | crescent, Hamilton drive. | 1878 |
| | Wilson, Charles, 6 Craigpark, Den- | | | |
| | nistoun. | 1875 | Yeaman, Charles H., 2 Albany | |
| | Wilson, David, Carbeth, by Killearn. | 1850 | place. | 1887 |
| 645 | Wilson, Peter M'Gregor, Rosevale, | | 660 Yellowlees, D., M.D., Medical | |
| | Bearsden. | 1877 | Superintendent, Gartnavel. | 1881 |
| | Wilson, Richard J., St. George's | | Young, George Christie, City Saw | |
| | Road Public School. | 1887 | Mills, Port-Dundas. | 1884 |
| | Wilson, William, Virginia buildings. | 1881 | Young, John, 22 Belhaven terrace, | |
| | Wilson, W. H., 45 Hope street. | 1881 | Kelvinside. | 1885 |
| | Wingate, Arthur, 6 Kelvin drive. | 1882 | Young, John, 234 Parliamentary | |
| 650* | Wingate, John B., 7 Crown terrace, | | road. | 1881 |
| | Dowanhill. | 1881 | Young, John, jun., M.A., B.Sc., 10 | |
| | Wingate, P., 14 Westbourne ter. | 1872 | Roxburgh street, Kelvinside. | 1887 |
| | Wingate, Walter E., 4 Bowmont | | 665 Young, R. Bruce, M.A., M.B., | |
| | terrace. | 1880 | C.M., University. | 1885 |
| | Wood, James, M.A., Glasgow | | Young, Robert, Carnock Villa, | |
| | Academy. | 1885 | Cambuslang. | 1875 |
| | Wood, James, 40 St. Enoch square. | 1886 | *Young, Thos. Graham, Westfield, | |
| 655 | Wood, Wm. Copland, Turkey-red | | West Calder. | 1880 |
| | Works, Alexandria. | 1883 | Younger, George, 166 Ingram st. | 1847 |
| | Woodburn, J. Cowan, M.D., 197 | | Zinkeisen, Victor, 30 Cochrane st. | 1881 |
| | Bath street. | 1869 | | |

THE FELL SPECIAL SOCIETY OF GLASGOW.

INVENTORY of all Property except the Library possessed by the Society—made by the Treasurer in compliance with Article XL of the Articles of Association and presented to the Annual Meeting on 16th November 1887.

I.—ITEMS, THE EXCLUSIVE PROPERTY OF THE SOCIETY.

All as detailed in Inventory of 1884, printed in *Proceedings* for 1884-85, Vol. XVI, pp. 465-6, and in those of 1885, printed in Vol. XVII, p. 468, and of 1886, printed in Vol. XVIII, p. 458, with the following addition:—

CROWN BOOK
Framed Photograph of M. Chevreul.

II.—ITEMS, THE PROPERTY OF THE SOCIETY JOINTLY WITH THE "INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND."

All as detailed in Inventory of 1884, printed in the *Proceedings* for 1884-85, Vol. XVI, pp. 466-7, and in that of 1885, printed in Vol. XVII, p. 468, and of 1886, printed in Vol. XVIII, p. 458.

JNO. MANN, *Treasurer.*

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